Relative Performance of ALFALFA Varieties, Variety Crosses, and Variety Mixtures

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Relative Performance of ALFALFA Varieties, Variety Crosses, and Variety Mixtures

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Alfalfa acreage expanded rapidly in the United States from 18.9 million acres in 1950 to about 29 million in 1961 (*20*).[8] New varieties and improved seed-production practices have been largely responsible for the increase.

Since the release of Atlantic, Ranger, and Buffalo in 1940, 1942, and 1943, respectively, alfalfa breeders have released 20 or more varieties with such special characteristics as winter hardiness and resistance to diseases and insects (*7*). These were predominantly synthetic varieties. Considerable interest has been expressed in variety crosses and blends.

This study was undertaken in 1956 to determine the relative performance of alfalfa varieties, variety crosses, and variety mixtures. Performance tests were conducted at nine locations in the north-central, north-Atlantic, and south-Atlantic regions. Information also was obtained on the relative importance of several variance components in evaluating diverse varieties for yield over a wide geographical area, and on the relative increase in efficiency of the triple lattice design over a randomized block design.

Varieties, crosses, and mixtures were evaluated primarily by hay yields. Disease and stand data were collected to aid in characterization of the varieties, but these data were not used for critical evaluations of crosses and mixtures. With the exception of Iowa, performance tests were conducted in 1959 and 1960. The Iowa test was conducted in 1960 and 1961. For that reason, Iowa data were treated only on a location basis and were not included in means and analysis for locations combined.

Terminology

Variety Cross: The term "variety cross" is used in this report with qualification. To obtain seed of a variety cross, the two parent varieties of the cross were planted in alternating rows so that they could be enclosed under a screen cage for pollination by honey bees. If the percentage of cross-pollination under cage conditions is the same as in the field, seed of a variety cross thus produced would be expected to result from different kinds of pollination in the following approximate proportions: (1) 45 percent from intervarietal crossing, (2) 45 percent from intravarietal crossing, and (3) 10 percent from self-pollination. If individual bees had preferences for varieties, the percentage of crossing between varieties would be reduced. Bee preferences for individual plants would increase the percentage of selfing. Varieties and climatic conditions probably would affect pollination also.

Thus, a variety cross of alfalfa in this report refers to a population in which individuals of intervarietal hybrid origin probably constitute less than half of the population. For practical considerations, it is assumed that each variety cross was primarily a mixture of two approximately equal parts—one consisting of hybrids between the two varieties and the other consisting of a composite of the two parent varieties.

Midparent: The term "midparent" is used to indicate the average of the two parents of a variety cross or of the two component varieties of a mixture.

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[8] Italic numbers in parentheses refer to Literature Cited, p. 23.

Review of Literature

Tysdal and Kiesselbach (*18*) have reviewed the literature on the extent of natural cross-pollination of alfalfa. They cited estimates of cross-fertilization as follows: Nebraska 89 percent, Canada 94 percent, and Argentina 85 percent. Bolton (*2*) of Canada reported a range from 11 to 100 percent among clones, but generally near 90 percent, of seed set in the field resulted from cross-pollination. Pedersen (*11*) of Utah estimated 86 percent natural crossing in the field. Estimates of percentages of crossing occurring when large numbers of genotypes are grown in a screen cage and pollinated by honey bees, as in the study reported here, are not available. Hanson et al. (*8*) indicated that considerably more selfing might occur on clones caged together and pollinated by honey bees than would be expected under natural conditions.

Inbreeding alfalfa results in a rapid loss of both vigor and self-fertility (*17*, *18*, *19*, *22*). Self-incompatibility interferes with development of true breeding lines.

Some information is available on the performance of alfalfa mixtures when components of the mixture differed in competitive ability. Tysdal and Kiesselbach (*18*) reported yields of Ladak alone, selfed progeny alone, and mixtures of the two as follows:

Proportions (percent)	*Actual yields*	*Theoretical yields*
	Percent	*Percent*
Ladak (100)	100	
Ladak (75) and selfed progeny (25)	96. 5	89. 5
Ladak (50) and selfed progeny (50)	89. 6	79. 0
Selfed progeny (100)	58. 0	

Ladak was chosen as the high-yielding component and selfed progeny (mostly one generation of selfing) of similar viability as the low-yielding component. The authors concluded that higher yielding plants benefited through competition with less vigorous and lower yielding plants, and a total production resulted nearer that of the high-yielding component. In another test the 50:50 mixture yielded relatively better when seeded at 24 pounds per acre than at 12 pounds, indicating that competitive effect is conditioned somewhat by seeding rate. According to Graber (*5*), a mixture of equal parts of Cossack and Ladak was superior in yield and persistence to either variety seeded alone. He concluded that this gave "some indication of the value of diversity among alfalfa plants of a variety designed to meet a wide range of use and environmental circumstances."

In pearl millet, mixtures of a hybrid and its two parental inbreds in proportions containing 90, 80, 50, and 20 percent of hybrid seed were compared with the pure hybrid (*3*). During a 6-year test period, the 90-, 80-, and 50-percent hybrid mixtures did not differ significantly in average forage production from that of the pure hybrid. Stand had a pronounced effect on yield performance of mixtures. About three or more seedlings per inch of row were required to give yield performance of mixtures comparable to that of 100-percent hybrid seed. It was believed that most, if not all, of the less vigorous seedlings from parents were eliminated by early competition and that thereafter the mixtures performed as hybrids.

Literature reviews by Mumaw and Weber (*10*) and Allard (*1*) indicated that variety mixtures yielded more than the average of the parent varieties in some self-pollinated crops.

Three soybean varieties were compared with their blends during a 4-year period (*14*). The varieties differed markedly in maturity and height, to some extent in growth type and lodging susceptibility, and in reaction to several diseases. In general, blends were not superior in yield to the highest yielding parent variety. The 13 blends averaged 2.2 percent higher in yield than the pure-line average. A marked variety × season interaction existed for yield, and blending had a stabilizing effect in this respect. Other information reported simultaneously (*10*) showed that on the average soybean variety blends in 1:1 ratios yielded 2 percent higher than the pure-line average. It was believed that most soybean blends would fail to yield higher than the highest yielding component pure line.

In lima beans, simple mechanical mixtures of two or three pure lines consistently produced less than the average of component pure lines grown singly (*1*). Genetically complex populations derived by bulk propagation from hybrids between the same parents yielded as much as the superior pure-line parent or more. The main difference between mixtures and pure stands of varieties in exploitation of the environment appeared related to competition for space (light). It was suggested that simple mixtures contained too few genotypes to be efficient in exploiting all available ecological sites. It was concluded that differences of morphology, physiological requirements, and growth rhythm of the many component types in complex blends apparently resulted in conditions that favored individual genotypes more than did the conditions with pure populations or simple mixtures, where individuals always or frequently competed with other individuals of similar morphology and simultaneous requirements. Pure-line populations were less stable in productivity than mixed populations. It was concluded that mixtures appeared to be insured against very low yields, but the genetic and ecological forces that produce stability in production do not necessarily endow mixtures with high average productive capacity.

Hanson et al. (*6*) determined the yield of five

apomictic Kentucky bluegrass strains grown individually in broadcast plots and as all possible composites of two, three, four, or five strains. The five strains represented a range in morphologic types. Eleven of twenty-six combinations exceeded the yield of the highest yielding component strains over a 2-year period. Six combinations yielded significantly more than the commercial check, though none of the pure strains significantly outyielded the check.

Materials and Methods

Genetic Background and Description of Parent Varieties

Alfalfa varieties grown in the United States were derived from three principal stocks found in nature—*Medicago sativa* L., *M. falcata* L., and an intermediate stock known as variegated alfalfa. Variegated alfalfa resulted from natural crossing between the two species, followed by natural selection. Persoon (*12, p. 356*) called variegated alfalfa *M. media,* but most workers prefer to include variegated alfalfa with *M. sativa.* Sprague (*16*) showed that *M. sativa* crossed readily with *M. falcata* and, from a cytological point of view, concluded that they were variations within one polymorphic species.

In this report the variegated alfalfas will be included in *M. sativa.* Thus, *M. sativa* includes (1) the purple-flowered varieties, such as Buffalo, Williamsburg, and Lahontan, and (2) the varieties with variegated flowers, such as Atlantic, Culver, Narragansett, Rambler, Ranger, and Vernal. The variegated group is more winter hardy than other forms of *M. sativa.* Variegated varieties were bred from naturally occurring forms of variegated origin. The parental lines of Narragansett, Vernal, Rambler, and Atlantic also included strains of *M. falcata. M. falcata* is yellow flowered and more winter hardy and decumbent than *M. sativa.* Also, *M. falcata* has greater root branching and a deeper set crown, but generally yields considerably less forage and seed. Most of the alfalfa acreage in the northern half of the United States and about two-thirds of the national acreage consist of variegated varieties.

Turkistan alfalfa is a name commonly applied to naturalized strains from Turkistan. It is an important source of resistance to bacterial wilt, stem nematode, and certain insects, but it is very susceptible to some foliar diseases. Lahontan was developed from Turkistan alfalfa. Ranger, Atlantic, Narragansett, and Culver derive part of their parentage from Turkistan. Turkistan and Flemish alfalfas are forms of *M. sativa* and are not sufficiently distinct to be called subspecies. Thus, commercial alfalfa varieties have a broad and complex genetic background.

National acreages of varieties used in this study are given in table 1 and are from Saunders (*15*). Information on Culver is unpublished data from Purdue University. The remaining information in table 1 is from Hanson et al. (*7*).

Producing Seed of Variety Crosses

Seed of parent varieties for most of the cross combinations was planted in the greenhouse at Beltsville, Md., during the winter of 1955–56. Seedlings were shipped to Bakersfield, Calif., for transplanting in the field. Seed for some of the combinations was planted directly in the field. Varieties were planted so that any one variety cross combination could be enclosed under a cage for pollination by honey bees. The planting for each cross consisted of six rows, 40 inches apart and 18 feet long, with three alternating rows of each variety. At least 125 seedlings of each variety were planted for each variety cross.

Plants were irrigated frequently after transplanting to enhance survival and to develop well-established plants for maximum seed yield. Frequent irrigation was discontinued at about caging time. Transplants survived well. Each cage was managed as an individual unit to obtain maximum seed production.

Cages were erected over each variety cross and maintained in a bee-tight condition until seed harvest. Cages were 20 by 20 by 6 feet. They were supported by a frame constructed from ½-inch zinc-coated conduit, and ¾-inch conduit was used for the corners. The cage cover was made from a plastic screen material. Other details of cage construction, bee management, insect control, and harvesting procedures were like those in a concurrent study reported by Hanson et al. (*8*). Variety seed yields under cage ranged from 161 to 502 pounds per acre and averaged 266.

Establishment of Test Plantings

Viable seed of reciprocals was mixed in equal proportions. Seed from harvests in the 2 years was then mixed in equal proportions to give one seed lot of each variety cross for progeny tests.

Fifteen variety crosses, eleven of the corresponding mixtures of the parent varieties (equal parts of viable seed of each parent), nine parent varieties, and a mass polycross were seeded at nine locations, as shown in table 2. Certified seed was used for planting varieties and variety mixtures. The mass polycross was constituted by compositing equal amounts of germinable seeds of 91 two-clone combinations evaluated in a separate study (*8*). Inclusion of the mass polycross was incidental to the main objectives of this study. Insufficient seed of Culver to include it in variety mixtures accounted for four fewer mixtures than variety crosses.

TABLE 1.—*Origin, description, and estimated U.S. acreage of parent varieties studied*

Variety	Origin	Characteristics	Winter hardiness	Area of adaptation	Estimated 1960 acreage	Percent of total acreage
					1,000 acres	
Atlantic	Composite of many lines, developed through program of maternal-line selection in stocks tracing to more than 100 varieties and strains from North America, Europe, and Asia. Some of these strains were of *Medicago falcata* origin. Released for seed increase in 1940.	Vigorous, high yielding; plants variable in growth habit. Dark-green foliage; flowers light purple with other colors and shades found occasionally. Not resistant to bacterial wilt organism, but somewhat tolerant.	Hardy, but somewhat less hardy than Ranger or Grimm.	Northeastern States to North Carolina and west to Mississippi River where bacterial wilt is not a serious factor.	392	1. 2
Buffalo	Developed from selections of old line of Kansas Common. Although not inbred, it was closebred, with attention given to bacterial wilt resistance and seed and forage productivity. Named in 1943.	Somewhat more upright and slightly quicker to recover than Kansas Common. Purple flowers and in other respects very similar to Kansas Common. Resistant to bacterial wilt.	Moderately hardy; similar to Kansas Common.	Overlaps southern limit of Ranger and extends farther south than Ranger. Grown in 400-mile-wide belt, with Kansas as center of belt.	2, 746	8. 6
Culver	4-clone synthetic. Parent clones selected from Hardigan, Cossack, and hybrid population of variegated alfalfa. Released in 1959.	Resistance to bacterial wilt and sufficient resistance to meadow spittlebug to perform well under moderate infestation without protection of insecticides. Some resistance to potato leafhopper and spotted alfalfa aphid.	Very winter hardy; similar to Ranger.	North Central States where meadow spittlebug is a problem.	--------	--------
Lahontan	5-clone synthetic selected from Nemastan. Released for seed increase in 1954.	Upright growth habit with quick recovery following cutting. Purple flowers. Resistant to bacterial wilt, stem nematode, and spotted alfalfa aphid. Very susceptible to foliar diseases.	Similar to Buffalo	Western States where bacterial wilt, stem nematode, and spotted alfalfa aphid are problems.	581	1. 8
Narragansett	Developed by mass selection from stocks consisting principally of crosses between *M. sativa* and *M. falcata*, Canadian Variegated, Cossack, Grimm, and Ladak. Named in 1946.	Vigorous. Plants vary from spreading to upright in growth habit. Wide crowns and dark-green foliage; variegated flowers. Very susceptible to bacterial wilt. Appears better adapted than most varieties to imperfectly drained soils in New York.	Very hardy	Northeastern and North Central States where bacterial wilt is not a problem.	456	1 4

Rambler	Developed through hybridization and selection for creeping-rooted characteristics. Ladak and Siberian (*M. falcata*) principal stocks used in original crosses. Licensed for sale in Canada in 1955.	Creeping rooted; low-set crown; variegated flowers. Drought resistant and winter hardy. Most forage obtained in first cutting. Yields less forage in United States than Vernal and Ranger. More resistant to bacterial wilt than Ladak, but not as resistant as Vernal or Ranger.	Very winter hardy	Northern Great Plains	1	
Ranger	Multiple-strain variety synthesized from five basic strains originating from Cossack (45 percent), Turkistan (45 percent), and Ladak (10 percent). Seed increase begun in 1940. Released in 1942.	Plants vary in growth habit from decumbent to upright. Variegated flowers. Quicker recovery after cutting than Ladak or Cossack and about equal to Grimm. Quite susceptible to leaf spot diseases, but more resistant than Turkistan. Slightly more susceptible to leafhopper yellowing than Grimm, but more resistant than Turkistan. Resistant to bacterial wilt.	Very hardy	Northern Great Plains and eastward.	9, 142	28. 6
Vernal	Synthetic released in 1953. Fifty percent of germ plasm in variety derived from six Cossack plants, remainder from crosses between selected plants of Ladak, Kansas Common, and diploid stock of *M. falcata*.	Good production of forage under hay and grazing management in North Central States. Fine stem, leafy, dark-green foliage, broad crowns, predominantly blue flowers, but range from yellow to purple, with many greenish blue. Similar to Cossack in recovery after cutting and fall dormancy. High level of winter hardiness and resistance to bacterial wilt. Tolerant to leaf spot and yellow leaf blotch.	Very hardy	Northern States	3, 814	12. 0
Williamsburg	Mass selection from Kansas Common. Seed increase begun in 1947.	Similar to Kansas Common in growth characteristics, except that it recovers somewhat more quickly after cutting and appears to have greater resistance to crown-rotting organisms occurring in Coastal Plains area of Virginia and North Carolina. Susceptible to bacterial wilt.	Similar to Kansas Common.	Mideastern States where bacterial wilt is not a problem.	176	. 5

TABLE 2.—*Soil type, seeding dates, methods, and plot size at indicated locations* [1]

Location	Soil type	Date seeded (1958)	Seeding method	Plot size	Area harvested
				Feet	*Square feet*
Lafayette, Ind.	Fincastle silt loam	Aug. 13	5-row drilled plots	3½ by 21	73. 5
Ames, Iowa	Clarion loam	Apr. 14 [2]	4-row drilled plots	3½ by 15	52. 5
Manhattan, Kans.	Sarpy fine sandy loam	Aug. 22	3-row drilled plots	2½ by 15	37. 5
Rosemount, Minn.	Clinton silt loam	May 23	Broadcast	5 by 15	46. 0
Lincoln, Nebr.	Sharpsburg silty clay loam.	Apr. 30 [2]	3-row drilled plots	2½ by 15	37. 5
Ithaca, N.Y.	Erie	May 21	Broadcast	5 by 16	40. 6
Raleigh, N.C.	Georgeville silty clay loam.	Sept. 1	3-row drilled plots	2½ by 15	37. 5
University Park, Pa.	Hagerstown silty clay loam.	May 15	Broadcast	5 by 20	60. 0
Madison, Wis.	Parr silt loam	June 11	do	5 by 25	79. 2

[1] 6 replications, except 4 at Madison.
[2] 1959.

A common seeding rate based on the amount of viable seed was used for varieties, crosses, and mixtures. A randomized complete block design was used at Madison, Wis., and a triple lattice design at all other locations. Seeding was in multiple-drilled rows or broadcast plots at rates recommended in the respective States. Data obtained from the two types of plots would be expected to be comparable. Cutting dates at the respective locations are given in table 3.

TABLE 3.—*Cutting dates at indicated locations for determining hay yield*

State	Year	1st cutting	2d cutting	3d cutting	4th cutting
Indiana	1959	June 13	July 20	Sept. 4	
	1960	June 5	July 27	Sept. 12	
Iowa	1960	June 15	July 20	Sept. 6	
	1961	June 16	do	Aug. 30	
Kansas	1959	June 3	July 6	Aug. 10	Sept. 14
	1960	May 21	June 27	Aug. 2	Sept. 5
Minnesota	1959	June 4	July 14	Aug. 25	
	1960	June 6	July 18	Aug. 23	
Nebraska	1959	July 9	Aug. 20		
	1960	June 16	July 15	Aug. 19	
New York	1959	June 24	Aug. 7	Sept. 23	
	1960	June 16	July 29	Sept. 14	
North Carolina	1959	May 5	June 9	Aug. 3	
	1960	do	June 7	July 13	Aug. 16
Pennsylvania	1959	June 8	July 21	Sept. 1	
	1960	June 1	July 18	Sept. 6	
Wisconsin	1959	June 2	July 17	Aug. 25	
	1960	do	July 20	Aug. 24	

Statistical Procedures

The analyses of variance followed procedures given by Cochran and Cox (*4, chap. 14*). The Duncan multiple range test was used for comparing means of treatments—crosses, mixtures, and parent varieties—and for identifying the best variety cross or mixture. The least significant differences, on the other hand, were used to test differences between means of crosses and mixtures with high, low, and midparent values.

Mean square expectations were derived for mean squares of interest (table 18), assuming a random model.

Results

Hay Yields

Yields of crosses, mixtures, and parent varieties for nine locations are given by cuttings, seasons, and 2-year averages in tables 21–29 in the appendix. They are summarized by seasons and 2-year averages for these locations in tables 4–12 and over eight combined locations in table 13. Iowa data were not included in the combined analysis because the test was conducted a year later. Variety mixtures with Culver were not included in any of the tests. The way each cross is listed, such as Buffalo × Ranger or Ranger × Buffalo, has no significance, because seed of the reciprocals had been composited for testing.

TABLE 4.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Lafayette, Ind.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Ton*	*Tons*	*Tons*
Atlantic	4. 03	3. 93	3. 85	3. 79	6. 11	5. 89	6. 01	6. 17	5. 01	4. 88	4. 96	5. 02
Buffalo	3. 82				5. 67				4. 75			
Atlantic	4. 03	3. 68	3. 66	3. 64	6. 11	5. 48	5. 68	5. 26	5. 01	4. 54	4. 65	4. 46
Lahontan	3. 33				4. 84				4. 07			
Atlantic	4. 03	3. 89	3. 79	3. 93	6. 11	5. 69	5. 68	5. 67	5. 01	4. 74	4. 73	4. 82
Narragansett	3. 75				5. 27				4. 48			
Atlantic	4. 03	3. 72	3. 96	3. 97	6. 11	5. 09	5. 61	5. 89	5. 01	4. 38	4. 82	4. 90
Rambler	3. 41				4. 08				3. 76			
Atlantic	4. 03	3. 94	3. 84	4. 12	6. 11	5. 77	5. 66	5. 80	5. 01	4. 84	4. 75	4. 95
Vernal	3. 84				5. 43				4. 66			
Buffalo	3. 82	3. 58	3. 63	3. 54	5. 67	5. 26	5. 57	5. 25	4. 75	4. 41	4. 61	4. 41
Lahontan	3. 33				4. 84				4. 07			
Narragansett	3. 75	3. 71	3. 88	3. 59	5. 27	5. 30	5. 79	5. 55	4. 48	4. 50	4. 83	4. 58
Williamsburg	3. 67				5. 34				4. 52			
Vernal	3. 84	3. 59	3. 82	3. 58	5. 43	5. 14	5. 49	5. 07	4. 66	4. 36	4. 68	4. 27
Lahontan	3. 33				4. 84				4. 07			
Vernal	3. 84	3. 79	3. 84	3. 80	5. 43	5. 40	5. 73	5. 41	4. 66	4. 60	4. 81	4. 60
Ranger	3. 74				5. 37				4. 53			
Vernal	3. 84	3. 63	3. 81	3. 80	5. 43	4. 76	5. 11	5. 36	4. 66	4. 21	4. 48	4. 59
Rambler	3. 41				4. 08				3. 76			
Vernal	3. 84	3. 76	3. 68	3. 86	5. 43	5. 38	5. 60	5. 68	4. 66	4. 59	4. 64	4. 76
Williamsburg	3. 67				5. 34				4. 52			
Atlantic	4. 03	3. 88	3. 77	------	6. 11	5. 74	5. 78	------	5. 01	4. 78	4. 80	------
Culver	3. 72				5. 38				4. 55			
Buffalo	3. 82	3. 77	3. 56	------	5. 67	5. 52	5. 83	------	4. 75	4. 65	4. 66	------
Culver	3. 72				5. 38				4. 55			
Narragansett	3. 75	3. 74	4. 02	------	5. 27	5. 32	5. 72	------	4. 48	4. 52	4. 87	------
Culver	3. 72				5. 38				4. 55			
Vernal	3. 84	3. 78	3. 90	------	5. 43	5. 40	5. 54	------	4. 66	4. 60	4. 77	------
Culver	3. 72				5. 38				4. 55			
Average:												
With Culver combinations:												
High parent	3. 90	3. 76	3. 80	------	5. 72	5. 41	5. 65	------	4. 80	4. 57	4. 74	------
Low parent	3. 61				5. 10				4. 35			
Without Culver combinations:												
High parent	3. 92	3. 75	3. 80	3. 78	5. 75	5. 38	5. 63	5. 56	4. 81	4. 55	4. 73	4. 67
Low parent	3. 57				5. 00				4. 29			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent		*5 percent* 0. 32	*1 percent* 0. 43			*5 percent* 0. 41	*1 percent* 0. 55			*5 percent* 0. 30	*1 percent* 0. 40	
Cross or mixture versus parent average		. 28	. 37			. 36	. 47			. 26	. 34	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent		. 10	. 13			. 12	. 16			. 09	. 12	

TABLE 5.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Ames, Iowa*

Variety combinations	1960				1961				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	4.83	4.71	4.63	4.85	3.72	3.66	3.53	3.67	4.27	4.18	4.08	4.26
Buffalo	4.59				3.59				4.09			
Atlantic	4.83	4.22	4.25	4.17	3.72	3.26	3.14	3.24	4.27	3.74	3.70	3.70
Lahontan	3.62				2.80				3.21			
Atlantic	4.83	4.87	4.91	4.82	3.72	3.66	3.62	3.49	4.27	4.26	4.26	4.16
Narragansett	4.91				3.61				4.26			
Atlantic	4.83	4.42	4.74	4.66	3.72	2.84	3.32	3.46	4.27	3.62	4.03	4.06
Rambler	4.01				1.96				2.98			
Atlantic	4.83	4.90	4.67	4.77	3.72	3.48	3.21	3.41	4.27	4.18	3.94	4.09
Vernal	4.96				3.25				4.10			
Buffalo	4.59	4.10	4.17	4.17	3.59	3.20	3.13	3.18	4.09	3.65	3.64	3.68
Lahontan	3.62				2.80				3.21			
Narragansett	4.91	4.78	4.90	4.70	3.61	3.68	3.75	3.68	4.26	4.23	4.33	4.19
Williamsburg	4.64				3.75				4.20			
Vernal	4.96	4.29	4.53	4.10	3.25	3.02	3.16	2.69	4.10	3.66	3.85	3.39
Lahontan	3.62				2.80				3.21			
Vernal	4.96	4.73	4.78	4.56	3.25	3.16	3.08	2.96	4.10	3.94	3.93	3.76
Ranger	4.50				3.07				3.79			
Vernal	4.96	4.48	4.86	4.70	3.25	2.60	2.92	3.03	4.10	3.54	3.89	3.86
Rambler	4.01				1.96				2.98			
Vernal	4.96	4.80	4.91	4.75	3.25	3.50	3.55	3.40	4.10	4.15	4.23	4.07
Williamsburg	4.64				3.75				4.20			
Atlantic	4.83	4.72	4.66	------	3.72	3.48	3.42	------	4.27	4.10	4.04	------
Culver	4.60				3.25				3.93			
Buffalo	4.59	4.60	4.67	------	3.59	3.42	3.46	------	4.09	4.01	4.06	------
Culver	4.60				3.25				3.93			
Narragansett	4.91	4.76	4.94	------	3.61	3.43	3.39	------	4.26	4.10	4.16	------
Culver	4.60				3.25				3.93			
Vernal	4.96	4.78	4.80	------	3.25	3.25	3.16	------	4.10	4.02	3.98	------
Culver	4.60				3.25				3.93			
Average:												
With Culver combinations:												
High parent	4.87	4.61	4.69	------	3.57	3.31	3.32	------	4.19	3.96	4.01	------
Low parent	4.35				3.05				3.72			
Without Culver combinations:												
High parent	4.88	4.57	4.67	4.57	3.59	3.28	3.31	3.29	4.20	3.92	3.99	3.93
Low parent	4.26				2.97				3.65			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent	*5 percent* 0.20		*1 percent* 0.27		*5 percent* 0.21		*1 percent* 0.27		*5 percent* 0.17		*1 percent* 0.22	
Cross or mixture versus parent average	.18		.23		.18		.24		.14		.19	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent	.06		.08		.06		.08		.05		.06	

TABLE 6.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Manhattan, Kans.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	7.58	7.54	7.15	7.16	7.66	7.66	7.69	7.30	7.64	7.61	7.42	7.23
Buffalo	7.50				7.66				7.58			
Atlantic	7.58	6.80	6.71	6.97	7.66	6.99	7.03	6.84	7.64	6.90	6.86	6.89
Lahontan	6.01				6.32				6.16			
Atlantic	7.58	6.93	7.00	7.40	7.66	6.88	7.03	7.48	7.64	6.92	7.02	7.44
Narragansett	6.28				6.10				6.20			
Atlantic	7.58	6.04	7.06	7.25	7.66	5.84	7.12	7.33	7.64	5.96	7.08	7.30
Rambler	4.50				4.03				4.28			
Atlantic	7.58	6.78	6.92	7.27	7.66	6.90	7.15	7.58	7.64	6.85	7.03	7.43
Vernal	5.97				6.15				6.06			
Buffalo	7.50	6.76	6.75	6.83	7.66	6.99	6.99	7.18	7.58	6.87	6.87	7.00
Lahontan	6.01				6.32				6.16			
Narragansett	6.28	6.61	7.00	6.89	6.10	6.78	7.14	7.27	6.20	6.70	7.08	7.07
Williamsburg	6.94				7.47				7.19			
Vernal	5.97	5.99	6.04	6.08	6.15	6.24	6.47	6.25	6.06	6.11	6.25	6.16
Lahontan	6.01				6.32				6.16			
Vernal	5.97	6.32	6.63	6.44	6.15	6.54	6.98	6.54	6.06	6.43	6.82	6.48
Ranger	6.66				6.94				6.80			
Vernal	5.97	5.23	5.66	5.97	6.15	5.09	5.77	5.98	6.06	5.17	5.73	5.99
Rambler	4.50				4.03				4.28			
Vernal	5.97	6.46	7.27	6.68	6.15	6.81	7.70	7.17	6.06	6.62	7.48	6.92
Williamsburg	6.94				7.47				7.19			
Atlantic	7.58	7.22	7.43	------	7.66	6.91	7.26	------	7.64	7.08	7.34	------
Culver	6.86				6.16				6.53			
Buffalo	7.50	7.18	7.23	------	7.66	6.91	7.37	------	7.58	7.06	7.30	------
Culver	6.86				6.16				6.53			
Narragansett	6.28	6.57	6.65	------	6.10	6.13	6.29	------	6.20	6.36	6.47	------
Culver	6.86				6.16				6.53			
Vernal	5.97	6.42	6.55	------	6.15	6.16	6.34	------	6.06	6.30	6.43	------
Culver	6.86				6.16				6.53			
Average:												
With Culver combinations:												
High parent	7.11	6.59	6.80	------	7.20	6.59	6.96	------	7.16	6.60	6.88	------
Low parent	6.06				5.98				6.03			
Without Culver combinations:												
High parent	7.08	6.49	6.74	6.81	7.30	6.61	7.01	6.98	7.20	6.56	6.88	6.90
Low parent	5.90				5.92				5.92			

L.S.D.:	1959		1960		2-year average	
	5 percent	*1 percent*	*5 percent*	*1 percent*	*5 percent*	*1 percent*
Within individual combinations:						
Cross versus mixture; cross or mixture versus high parent	0.43	0.57	0.44	0.58	0.40	0.53
Cross or mixture versus parent average	.37	.49	.38	.51	.34	.36
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent	.13	.17	.13	.18	.12	.16

TABLE 7.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, St. Paul, Minn.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	4.73	4.60	4.54	4.69	4.72	4.79	4.89	5.01	4.73	4.71	4.72	4.81
Buffalo	4.46				4.86				4.69			
Atlantic	4.73	3.05	4.13	4.28	4.72	4.00	4.75	4.83	4.73	3.54	4.46	4.55
Lahontan	1.36				3.29				2.35			
Atlantic	4.73	4.85	4.73	5.01	4.72	4.74	4.93	5.09	4.73	4.78	4.86	5.02
Narragansett	4.97				4.76				4.84			
Atlantic	4.73	4.74	4.80	4.65	4.72	4.52	4.68	4.78	4.73	4.63	4.73	4.68
Rambler	4.74				4.33				4.53			
Atlantic	4.73	4.88	4.66	4.85	4.72	4.82	4.73	4.86	4.73	4.87	4.74	4.85
Vernal	5.02				4.93				5.01			
Buffalo	4.46	2.91	4.04	4.25	4.86	4.08	4.81	4.68	4.69	3.52	4.49	4.43
Lahontan	1.36				3.29				2.35			
Narragansett	4.97	4.54	4.58	4.70	4.76	4.64	4.82	4.75	4.84	4.57	4.72	4.72
Williamsburg	4.18				4.51				4.30			
Vernal	5.02	3.19	4.54	4.74	4.93	4.11	4.93	4.90	5.01	3.68	4.77	4.79
Lahontan	1.36				3.29				2.35			
Vernal	5.02	4.75	4.58	4.86	4.93	4.88	4.77	4.78	5.01	4.82	4.72	4.77
Ranger	4.47				4.82				4.64			
Vernal	5.02	4.88	4.99	5.02	4.93	4.63	4.65	4.81	5.01	4.77	4.90	4.93
Rambler	4.74				4.33				4.53			
Vernal	5.02	4.60	4.70	4.85	4.93	4.72	4.88	4.93	5.01	4.66	4.82	4.87
Williamsburg	4.18				4.51				4.30			
Atlantic	4.73	4.80	4.83	------	4.72	4.68	4.73	------	4.73	4.71	4.77	------
Culver	4.86				4.64				4.69			
Buffalo	4.46	4.66	4.51	------	4.86	4.75	4.92	------	4.69	4.69	4.72	------
Culver	4.86				4.64				4.69			
Narragansett	4.97	4.92	5.07	------	4.76	4.70	4.92	------	4.84	4.76	4.95	------
Culver	4.86				4.64				4.69			
Vernal	5.02	4.94	5.04	------	4.93	4.78	4.83	------	5.01	4.85	4.95	------
Culver	4.86				4.64				4.69			
Average:												
With Culver combinations:												
High parent	4.89	4.42	4.65	------	4.84	4.59	4.82	------	4.86	4.50	4.75	------
Low parent	3.95				4.34				4.15			
Without Culver combinations:												
High parent	4.88	4.27	4.57	4.72	4.85	4.54	4.80	4.86	4.87	4.41	4.72	4.77
Low parent	3.66				4.23				3.95			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent		*5 percent* 0.28	*1 percent* 0.38			*5 percent* 0.27	*1 percent* 0.36			*5 percent* 0.20	*1 percent* 0.27	
Cross or mixture versus parent average		.25	.33			.24	.31			.18	.23	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent		.09	.12			.08	.11			.06	.08	

TABLE 8.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Lincoln, Nebr.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	2. 16	2. 15	2. 17	2. 14	5. 55	5. 36	5. 52	5. 47	3. 89	3. 78	3. 87	3. 79
Buffalo	2. 13				5. 18				3. 66			
Atlantic	2. 16	1. 98	1. 98	2. 05	5. 55	5. 04	5. 38	4. 88	3. 89	3. 51	3. 68	3. 46
Lahontan	1. 80				4. 52				3. 13			
Atlantic	2. 16	2. 18	2. 23	2. 19	5. 55	5. 38	5. 48	5. 41	3. 89	3. 79	3. 86	3. 80
Narragansett	2. 20				5. 20				3. 69			
Atlantic	2. 16	2. 14	2. 20	2. 14	5. 55	5. 12	5. 36	5. 49	3. 89	3. 64	3. 80	3. 82
Rambler	2. 12				4. 68				3. 38			
Atlantic	2. 16	2. 23	2. 19	2. 31	5. 55	5. 50	5. 27	5. 44	3. 89	3. 87	3. 73	3. 89
Vernal	2. 29				5. 45				3. 85			
Buffalo	2. 13	1. 97	2. 00	1. 93	5. 18	4. 85	5. 27	5. 03	3. 66	3. 40	3. 66	3. 46
Lahontan	1. 80				4. 52				3. 13			
Narragansett	2. 20	2. 19	2. 32	2. 15	5. 20	5. 26	5. 33	5. 27	3. 69	3. 72	3. 83	3. 69
Williamsburg	2. 17				5. 32				3. 74			
Vernal	2. 29	2. 05	2. 13	1. 99	5. 45	4. 98	5. 22	4. 87	3. 85	3. 49	3. 68	3. 43
Lahontan	1. 80				4. 52				3. 13			
Vernal	2. 29	2. 22	2. 13	2. 14	5. 45	5. 38	5. 35	5. 24	3. 85	3. 78	3. 75	3. 68
Ranger	2. 15				5. 30				3. 71			
Vernal	2. 29	2. 21	2. 28	2. 25	5. 45	5. 06	5. 35	5. 32	3. 85	3. 62	3. 82	3. 79
Rambler	2. 12				4. 68				3. 38			
Vernal	2. 29	2. 23	2. 27	2. 21	5. 45	5. 38	5. 40	5. 21	3. 85	3. 80	3. 84	3. 74
Williamsburg	2. 17				5. 32				3. 74			
Atlantic	2. 16	2. 19	2. 20	------	5. 55	5. 41	5. 45	------	3. 89	3. 82	3. 83	------
Culver	2. 21				5. 27				3. 75			
Buffalo	2. 13	2. 17	2. 10	------	5. 18	5. 22	5. 11	------	3. 66	3. 70	3. 60	------
Culver	2. 21				5. 27				3. 75			
Narragansett	2. 20	2. 21	2. 29	------	5. 20	5. 24	5. 31	------	3. 69	3. 72	3. 78	------
Culver	2. 21				5. 27				3. 75			
Vernal	2. 29	2. 25	2. 33	------	5. 45	5. 36	5. 71	------	3. 85	3. 80	4. 01	------
Culver	2. 21				5. 27				3. 75			
Average:												
With Culver combinations:												
High parent	2. 23	2. 16	2. 19	------	5. 44	5. 24	5. 37	------	3. 83	3. 70	3. 78	------
Low parent	2. 09				5. 03				3. 56			
Without Culver combinations:												
High parent	2. 22	2. 14	2. 17	2. 14	5. 46	5. 21	5. 36	5. 24	3. 84	3. 67	3. 77	3. 69
Low parent	2. 05				4. 96				3. 50			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent		*5 percent* 0. 14	*1 percent* 0. 19			*5 percent* 0. 33	*1 percent* 0. 44			*5 percent* 0. 19	*1 percent* 0. 25	
Cross or mixture versus parent average		. 12	. 17			. 29	. 38			. 17	. 22	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent		. 04	. 06			. 10	. 13			. 06	. 08	

TABLE 9.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Ithaca, N.Y.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	5.47	5.28	5.21	5.21	4.06	3.92	3.80	4.16	4.79	4.60	4.51	4.61
Buffalo	5.08				3.78				4.42			
Atlantic	5.47	4.89	4.78	5.22	4.06	3.66	3.76	4.01	4.79	4.26	4.28	4.57
Lahontan	4.31				3.27				3.74			
Atlantic	5.47	5.46	5.47	5.31	4.06	4.08	4.05	4.22	4.79	4.78	4.82	4.76
Narragansett	5.45				4.09				4.77			
Atlantic	5.47	5.07	5.35	5.18	4.06	3.80	4.08	4.02	4.79	4.47	4.71	4.65
Rambler	4.67				3.55				4.15			
Atlantic	5.47	5.49	5.27	5.54	4.06	4.16	4.04	4.25	4.79	4.84	4.69	4.89
Vernal	5.51				4.26				4.90			
Buffalo	5.08	4.70	4.81	4.78	3.78	3.52	3.59	3.75	4.42	4.08	4.25	4.30
Lahontan	4.31				3.27				3.74			
Narragansett	5.45	5.23	5.48	5.22	4.09	4.02	4.16	4.05	4.77	4.62	4.84	4.60
Williamsburg	5.00				3.94				4.46			
Vernal	5.51	4.91	5.13	5.19	4.26	3.76	3.97	3.92	4.90	4.32	4.63	4.59
Lahontan	4.31				3.27				3.74			
Vernal	5.51	5.24	5.31	5.14	4.26	4.08	4.18	3.92	4.90	4.66	4.68	4.53
Ranger	4.97				3.89				4.41			
Vernal	5.51	5.09	5.39	5.41	4.26	3.90	3.93	3.95	4.90	4.52	4.64	4.66
Rambler	4.67				3.55				4.15			
Vernal	5.51	5.26	5.24	5.15	4.26	4.10	4.04	3.85	4.90	4.68	4.60	4.54
Williamsburg	5.00				3.94				4.46			
Atlantic	5.47	5.28	5.43	------	4.06	3.94	3.98	------	4.79	4.59	4.68	------
Culver	5.08				3.82				4.39			
Buffalo	5.08	5.08	5.21	------	3.78	3.80	3.87	------	4.42	4.40	4.60	------
Culver	5.08				3.82				4.39			
Narragansett	5.45	5.27	5.39	------	4.09	3.96	4.10	------	4.77	4.58	4.75	------
Culver	5.08				3.82				4.39			
Vernal	5.51	5.30	5.28	------	4.26	4.04	4.02	------	4.90	4.64	4.69	------
Culver	5.08				3.82				4.39			
Average:												
With Culver combinations:												
High parent	5.43	5.17	5.25	------	4.11	3.92	3.97	------	4.78	4.54	4.62	------
Low parent	4.90				3.72				4.29			
Without Culver combinations:												
High parent	5.45	5.15	5.22	5.21	4.13	3.91	3.96	4.01	4.80	4.53	4.60	4.61
Low parent	4.84				3.69				4.26			

L.S.D.:	1959		1960		2-year average	
	5 percent	*1 percent*	*5 percent*	*1 percent*	*5 percent*	*1 percent*
Within individual combinations:						
Cross versus mixture; cross or mixture versus high parent	0.30	0.40	0.25	0.33	0.21	0.28
Cross or mixture versus parent average	.26	.34	.22	.29	.19	.24
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent	.09	.12	.08	.10	.06	.09

TABLE 10.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Raleigh, N.C.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	3.53	3.38	3.24	3.41	3.51	3.49	3.62	3.49	3.52	3.42	3.42	3.43
Buffalo	3.22				3.47				3.32			
Atlantic	3.53	3.13	3.07	3.12	3.51	3.14	3.28	3.29	3.52	3.14	3.18	3.19
Lahontan	2.73				2.78				2.76			
Atlantic	3.53	3.37	3.35	3.41	3.51	3.46	3.66	3.56	3.52	3.42	3.50	3.52
Narragansett	3.21				3.41				3.31			
Atlantic	3.53	2.95	3.24	3.16	3.51	2.97	3.47	3.41	3.52	2.98	3.35	3.25
Rambler	2.37				2.43				2.43			
Atlantic	3.53	3.50	3.33	3.54	3.51	3.44	3.52	3.61	3.52	3.46	3.45	3.57
Vernal	3.47				3.36				3.41			
Buffalo	3.22	2.98	2.98	2.96	3.47	3.12	3.23	3.16	3.32	3.04	3.09	3.05
Lahontan	2.73				2.78				2.76			
Narragansett	3.21	3.18	3.46	3.31	3.41	3.41	3.51	3.53	3.31	3.30	3.51	3.43
Williamsburg	3.16				3.41				3.28			
Vernal	3.47	3.10	3.37	3.07	3.36	3.07	3.29	3.06	3.41	3.08	3.35	3.06
Lahontan	2.73				2.78				2.76			
Vernal	3.47	3.31	3.19	3.38	3.36	3.28	3.20	3.34	3.41	3.28	3.22	3.41
Ranger	3.14				3.19				3.16			
Vernal	3.47	2.92	3.09	2.22	3.36	2.90	3.23	3.25	3.41	2.92	3.21	3.22
Rambler	2.37				2.43				2.43			
Vernal	3.47	3.32	3.11	3.25	3.36	3.38	3.46	3.42	3.41	3.34	3.28	3.33
Williamsburg	3.16				3.41				3.28			
Atlantic	3.53	3.22	3.40	------	3.51	3.35	3.52	------	3.52	3.30	3.48	------
Culver	2.91				3.19				3.07			
Buffalo	3.22	3.07	3.05	------	3.47	3.33	3.35	------	3.32	3.20	3.15	------
Culver	2.91				3.19				3.07			
Narragansett	3.21	3.06	3.17	------	3.41	3.30	3.24	------	3.31	3.19	3.18	------
Culver	2.91				3.19				3.07			
Vernal	3.47	3.19	3.14	------	3.36	3.28	3.44	------	3.41	3.24	3.27	------
Culver	2.91				3.19				3.07			
Average:												
With Culver combinations:												
High parent	3.43	3.19	3.21	------	3.44	3.26	3.40	------	3.43	3.22	3.31	------
Low parent	2.93				3.08				3.01			
Without Culver combinations:												
High parent	3.45	3.20	3.22	3.26	3.45	3.24	3.41	3.37	3.44	3.22	3.32	3.31
Low parent	2.94				3.04				2.99			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent		*5 percent* 0.29	*1 percent* 0.39			*5 percent* 0.20	*1 percent* 0.26			*5 percent* 0.20	*1 percent* 0.26	
Cross or mixture versus parent average		.25	.34			.17	.23			.17	.22	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent		.09	.12			.04	.06			----	----	

TABLE 11.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, University Park, Pa.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	4. 68	4. 45	4. 25	4. 50	4. 29	4. 14	4. 32	3. 96	4. 48	4. 31	4. 33	4. 25
Buffalo	4. 21				4. 00				4. 14			
Atlantic	4. 68	4. 05	4. 16	4. 31	4. 29	3. 88	3. 95	4. 20	4. 48	3. 94	4. 05	4. 21
Lahontan	3. 42				3. 47				3. 41			
Atlantic	4. 68	4. 72	4. 69	4. 79	4. 29	4. 20	4. 28	4. 39.	4. 48	4. 48	4. 50	4. 58
Narragansett	4. 75				4. 11				4. 48			
Atlantic	4. 68	4. 36	4. 60	4. 38	4. 29	3. 58	4. 17	4. 15	4. 48	3. 96	4. 41	4. 26
Rambler	4. 04				2. 86				4. 43			
Atlantic	4. 68	4. 87	4. 66	4. 79	4. 29	4. 37	4. 34	4. 46	4. 48	4. 60	4. 47	4. 55
Vernal	5. 05				4. 45				4. 72			
Buffalo	4. 21	3. 82	4. 05	3. 86	4. 00	3. 74	3. 73	3. 73	4. 14	3. 78	3. 90	3. 80
Lahontan	3. 42				3. 47				3. 41			
Narragansett	4. 75	4. 47	4. 63	4. 76	4. 11	4. 07	4. 23	4. 17	4. 48	4. 26	4. 48	4. 39
Williamsburg	4. 18				4. 03				4. 03			
Vernal	5. 05	4. 24	4. 24	4. 20	4. 45	3. 96	4. 17	3. 99	4. 72	4. 06	4. 21	4. 10
Lahontan	3. 42				3. 47				3. 41			
Vernal	5. 05	4. 68	4. 64	4. 64	4. 45	4. 10	4. 07	4. 05	4. 72	4. 37	4. 37	4. 31
Ranger	4. 31				3. 74				4. 02			
Vernal	5. 05	4. 55	4. 55	4. 45	4. 45	3. 66	3. 99	3. 96	4. 72	4. 08	4. 31	4. 20
Rambler	4. 04				2. 86				3. 43			
Vernal	5. 05	4. 62	4. 69	4. 61	4. 45	4. 24	4. 07	4. 15	4. 72	4. 38	4. 35	4. 33
Williamsburg	4. 18				4. 03				4. 03			
Atlantic	4. 68	4. 65	4. 71	------	4. 29	4. 06	4. 24	------	4. 48	4. 34	4. 49	------
Culver	4. 61				3. 84				4. 19			
Buffalo	4. 21	4. 41	4. 62	------	4. 00	3. 92	4. 09	------	4. 14	4. 16	4. 34	------
Culver	4. 61				3. 84				4. 19			
Narragansett	4. 75	4. 68	4. 69	------	4. 11	3. 98	4. 17	------	4. 48	4. 34	4. 46	------
Culver	4. 61				3. 84				4. 19			
Vernal	5. 05	4. 83	4. 74	------	4. 45	4. 14	4. 19	------	4. 72	4. 46	4. 48	------
Culver	4. 61				3. 84				4. 19			
Average:												
With Culver combinations:												
High parent	4. 81	4. 49	4. 53	------	4. 29	4. 00	4. 13	------	4. 53	4. 23	4. 34	------
Low parent	4. 18				3. 71				4. 00			
Without Culver combinations:												
High parent	4. 82	4. 44	4. 47	4. 48	4. 32	3. 99	4. 12	4. 11	4. 56	4. 20	4. 31	4. 27
Low parent	4. 05				3. 67				3. 93			
L.S.D.:												
Within individual combinations:												
Cross versus mixture; cross or mixture versus high parent		*5 percent* 0. 33	*1 percent* 0. 43			*5 percent* 0. 33	*1 percent* 0. 44			*5 percent* 0. 28	*1 percent* 0. 36	
Cross or mixture versus parent average		. 28	. 37			. 29	. 38			. 24	. 32	
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent		. 10	. 13			---	----			. 08	. 11	

TABLE 12.—*Comparison of seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties, Madison, Wis.*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	4.13	4.00	3.85	3.83	4.81	4.77	4.86	4.87	4.47	4.38	4.35	4.35
Buffalo	3.88				4.73				4.30			
Atlantic	4.13	3.52	3.50	3.61	4.81	4.36	4.62	4.57	4.47	3.94	4.06	4.09
Lahontan	2.91				3.92				3.41			
Atlantic	4.13	4.22	4.07	4.08	4.81	4.78	4.64	4.82	4.47	4.50	4.36	4.45
Narragansett	4.32				4.76				4.54			
Atlantic	4.13	4.26	4.50	4.38	4.81	4.11	4.28	4.57	4.47	4.18	4.39	4.47
Rambler	4.40				3.41				3.90			
Atlantic	4.13	4.22	4.30	4.24	4.81	4.72	4.66	4.78	4.47	4.48	4.48	4.51
Vernal	4.32				4.63				4.48			
Buffalo	3.88	3.40	3.76	3.28	4.73	4.32	4.50	4.51	4.30	3.86	4.13	3.90
Lahontan	2.91				3.92				3.41			
Narragansett	4.32	4.14	3.61	4.30	4.76	4.81	4.89	4.90	4.54	4.48	4.25	4.60
Williamsburg	3.97				4.86				4.42			
Vernal	4.32	3.61	3.99	4.09	4.63	4.28	4.73	4.44	4.48	3.94	4.36	4.27
Lahontan	2.91				3.92				3.41			
Vernal	4.32	4.18	4.32	4.58	4.63	4.58	4.66	4.61	4.48	4.39	4.49	4.60
Ranger	4.05				4.54				4.30			
Vernal	4.32	4.36	4.66	4.96	4.63	4.02	4.39	4.43	4.48	4.19	4.53	4.70
Rambler	4.40				3.41				3.90			
Vernal	4.32	4.14	3.88	4.01	4.63	4.74	5.07	4.76	4.48	4.45	4.48	4.38
Williamsburg	3.97				4.86				4.42			
Atlantic	4.13	4.20	3.95	------	4.81	4.66	4.67	------	4.47	4.44	4.31	------
Culver	4.28				4.52				4.40			
Buffalo	3.88	4.08	4.14	------	4.73	4.62	4.89	------	4.30	4.35	4.51	------
Culver	4.28				4.52				4.40			
Narragansett	4.32	4.30	4.65	------	4.76	4.64	4.76	------	4.54	4.47	4.71	------
Culver	4.28				4.52				4.40			
Vernal	4.32	4.30	4.21	------	4.63	4.58	4.87	------	4.48	4.44	4.54	------
Culver	4.28				4.52				4.40			
Average:												
With Culver combinations:												
High parent	4.27	4.06	4.09	------	4.75	4.53	4.70	------	4.47	4.30	4.40	------
Low parent	3.86				4.31				4.13			
Without Culver combinations:												
High parent	4.26	4.01	4.04	4.12	4.76	4.50	4.66	4.66	4.47	4.25	4.35	4.39
Low parent	3.76				4.24				4.04			

L.S.D.:	1959		1960		2-year average	
	5 percent	*1 percent*	*5 percent*	*1 percent*	*5 percent*	*1 percent*
Within individual combinations:						
Cross versus mixture; cross or mixture versus high parent	0.53	0.70	0.23	0.31	0.32	0.42
Cross or mixture versus parent average	.46	.60	.20	.26	.27	.36
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent	.16	.21	----	----	.10	.13

TABLE 13.—*Comparison of adjusted, seasonal hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties averaged over all locations except Iowa*

Variety combinations	1959				1960				2-year average			
	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture	Parents	Average	Cross	Mixture
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Atlantic	4.54	4.42	4.28	4.34	5.07	4.98	5.04	5.04	4.83	4.73	4.71	4.70
Buffalo	4.29				4.89				4.62			
Atlantic	4.54	3.88	4.00	4.15	5.07	4.54	4.75	4.68	4.83	4.23	4.42	4.44
Lahontan	3.23				4.01				3.64			
Atlantic	4.54	4.42	4.42	4.52	5.07	4.90	4.97	5.06	4.83	4.68	4.72	4.81
Narragansett	4.30				4.73				4.54			
Atlantic	4.54	4.16	4.46	4.39	5.07	4.39	4.86	4.94	4.83	4.28	4.67	4.67
Rambler	3.78				3.72				3.73			
Atlantic	4.54	4.48	4.39	4.58	5.07	4.96	4.90	5.07	4.83	4.74	4.68	4.84
Vernal	4.43				4.86				4.64			
Buffalo	4.29	3.76	4.00	3.93	4.89	4.45	4.66	4.61	4.62	4.13	4.39	4.31
Lahontan	3.23				4.01				3.64			
Narragansett	4.30	4.23	4.37	4.36	4.73	4.78	4.98	4.91	4.54	4.52	4.71	4.64
Williamsburg	4.16				4.83				4.50			
Vernal	4.43	3.83	4.16	4.12	4.86	4.43	4.76	4.51	4.64	4.14	4.50	4.34
Lahontan	3.23				4.01				3.64			
Vernal	4.43	4.28	4.33	4.37	4.86	4.78	4.87	4.72	4.64	4.55	4.61	4.55
Ranger	4.12				4.70				4.45			
Vernal	4.43	4.10	4.30	4.38	4.86	4.29	4.59	4.65	4.64	4.18	4.45	4.50
Rambler	3.78				3.72				3.73			
Vernal	4.43	4.30	4.36	4.33	4.86	4.84	5.01	4.88	4.64	4.57	4.70	4.62
Williamsburg	4.16				4.83				4.50			
Atlantic	4.54	4.43	4.46	------	5.07	4.84	4.93	------	4.83	4.64	4.73	------
Culver	4.32				4.61				4.45			
Buffalo	4.29	4.30	4.30	------	4.89	4.75	4.90	------	4.62	4.53	4.61	------
Culver	4.32				4.61				4.45			
Narragansett	4.30	4.31	4.49	------	4.73	4.67	4.83	------	4.54	4.49	4.64	------
Culver	4.32				4.61				4.45			
Vernal	4.43	4.37	4.40	------	4.86	4.73	4.86	------	4.64	4.54	4.65	------
Culver	4.32				4.61				4.45			
Average:												
With Culver combinations:												
High parent	4.44	4.22	4.31	------	4.94	4.69	4.86	------	4.70	4.46	4.61	------
Low parent	4.00				4.44				4.23			
Without Culver combinations:												
High parent	4.46	4.17	4.28	4.32	4.96	4.67	4.85	4.82	4.72	4.43	4.60	4.58
Low parent	3.88				4.38				4.15			

	1959		1960		2-year average	
L.S.D.:						
Within individual combinations:						
Cross versus mixture; cross or mixture versus high parent	*5 percent* 0.12	*1 percent* 0.16	*5 percent* 0.11	*1 percent* 0.15	*5 percent* 0.09	*1 percent* 0.13
Cross or mixture versus parent average	.11	.14	.10	.13	.08	.11
Average without Culver combinations: Cross versus mixture; cross or mixture versus high parent	.04	.05	.03	.05	.03	.04

Mean Squares From Analyses of Variance

Within Locations

Mean squares from the analyses of variance for locations, years, and years combined within locations are given in tables 14–17. Differences among alfalfa treatments and years were highly significant (table 16). The year × treatment interactions were highly significant except in Nebraska, North Carolina, and New York. Relative efficiency of the lattice design as compared with the randomized block design ranged from 112 percent at Kansas to 174 percent at Pennsylvania for the combined 1959 and 1960 seasonal yields. This result is in agreement with results of previous studies (*21*).

TABLE 14.—*Mean squares from analyses of variance of 1959 seasonal hay yields for all locations except Iowa*

Source of variation	d.f.[1]	Indiana	Minnesota	Nebraska	North Carolina	Pennsylvania	Wisconsin [1]	Kansas	New York
Replications	5	2. 4640	0. 4260	0. 3980	1. 9560	1. 3500	2. 9139	0. 6640	0. 6520
Treatments:									
Unadjusted	35	. 1926	2. 2517	. 0969	. 3760	. 6469	. 6317**	2. 4011	. 4857
Adjusted	35	. 1560**	2. 0303**	. 0846**	. 2926**	. 5537**	----	2. 4091**	. 4703**
Blocks	30	. 2800	. 1417	. 0840	. 3287	. 4563	----	. 2250	. 4563
Component a	15	. 3253	. 1667	. 0800	. 4453	. 6447	----	. 0647	. 4700
Component b	15	. 2347	. 1167	. 0880	. 2120	. 2680	----	. 3853	. 4427
Intrablock error	145	. 0753	. 0574	. 0137	. 0570	. 0690	----	. 1303	. 0583
Randomized block error	175	. 1104	. 0718	. 0257	. 1035	. 1354	. 1409	. 1466	. 1266
Effective error	----	. 0806	. 0636	. 0159	. 0655	. 0811	----	. 1404	. 0685
μ^2	----	. 0588	. 0453	. 0671	. 0660	. 0681	----	. 0307	. 0704
Relative efficiency (percent)	----	137	114	156	158	167	----	104	185
Coefficient of variation (percent)	----	8	6	6	8	6	9	6	5

[1] Wisconsin test had only 4 replications and was analyzed as a randomized block with degrees of freedom as follows: Total 143, replications 3, treatments 35, and error 105.
[2] Weighting factor used by Cochran and Cox (*4, p. 407*).
**Indicates significance at 1-percent level.

TABLE 15.—*Mean squares from analyses of variance of 1960 seasonal hay yields for all locations except Iowa*

Source of variation	d.f.[1]	Indiana	Minnesota	Nebraska	North Carolina	Pennsylvania	Wisconsin [1]	Iowa	Kansas	New York
Replications	5	0. 5331	0. 7211	0. 8298	0. 3272	2. 2818	0. 0662	0. 7723	2. 3204	0. 2737
Treatments:										
Unadjusted	35	. 8676	. 4941	. 3810	. 3394	. 5523	. 3540**	. 5831	3. 0736	. 3055
Adjusted	35	. 7681**	. 4327**	. 3219**	. 3273**	. 4733**	----	. 4931**	3. 0834**	. 2240**
Blocks	30	. 2958	. 3014	. 1683	. 0710	. 3140	----	. 0952	. 3095	. 2266
Component a	15	. 3912	. 5234	. 2006	. 0621	. 4499	----	. 0843	. 1162	. 1741
Component b	15	. 2003	. 0795	. 1360	. 0799	. 1781	----	. 1061	. 5028	. 2791
Intrablock error	145	. 1166	. 0486	. 0763	. 0270	. 0735	----	. 0279	. 1349	. 0411
Randomized block error	175	. 1473	. 0919	. 0921	. 0345	. 1148	. 0270	. 0395	. 1648	. 0729
Effective error	----	. 1308	. 0570	. 0840	. 0303	. 0855	----	. 0319	. 1497	. 0479
μ^2	----	. 0459	. 0672	. 0410	. 0472	. 0602	----	. 0547	. 0424	. 0653
Relative efficiency (percent)	----	113	161	110	114	134	----	124	110	152
Coefficient of variation (percent)	----	6. 6	5. 0	5. 5	5. 2	7. 2	3. 6	3. 9	5. 7	5. 6

[1] See table 14, footnote 1.
[2] See table 14, footnote 2.
**Indicates significance at 1-percent level.

TABLE 16.—*Mean squares from analyses of variance of combined 1959 and 1960 seasonal hay yields for al locations except Iowa*

Source of variation	d.f.[1]	Indiana	Minnesota	Nebraska	North Carolina	Pennsylvania	Wisconsin[1]	Kansas	New York
Whole plots	215	0. 2998	0. 4425	0. 1270	0. 2144	0. 4092	0. 2355	1. 1461	0. 2295
Replications	5	1. 8576	. 1621	. 3008	1. 3544	3. 3932	1. 9118	2. 6643	. 7085
Treatments:									
Unadjusted	35	. 7759	2. 2265	. 3759	. 6486	1. 0231	. 4921**	5. 3013	. 7086
Adjusted	35	. 7361**	2. 0794**	. 3309**	. 5983**	. 9389**	----------	5. 3065**	. 6135**
Blocks	30	. 3122	. 2662	. 1722	. 2904	. 6622	----------	. 4743	. 3915
Component a	15	. 3869	. 4202	. 2106	. 3504	1. 0155	----------	. 1268	. 3152
Component b	15	. 2375	. 1123	. 1337	. 2303	. 3089	----------	. 8219	. 4678
Intrablock error	145	. 1286	. 0580	. 0516	. 0545	. 1058	----------	. 2298	. 0639
Randomized block error (a)	175	. 1601	. 0937	. 0723	. 0949	. 2012	. 1021	. 2717	. 1201
Years	1	328. 5138**	3. 3743**	1046. 8894**	2. 2997**	18. 5836**	20. 5708**	1. 6713**	165. 3795**
Years × treatments	35	. 2843**	. 5193**	. 1020	. 0668	. 1760**	. 4935**	. 1735**	. 0827
Randomized block error (b)	180	. 1266	. 0955	. 0700	. 0677	. 0543	. 0937	. 0475	. 0832
Effective error	----	. 1369	. 0626	. 0559	. 0588	. 1159	----------	. 2422	. 0699
μ[2]	----	. 0221	. 0309	. 0270	. 0324	. 0336	----------	. 0191	. 0335
Relative efficiency (percent)	----	117	150	129	161	174	----------	112	172
Coefficient of variation (percent)	----	8. 0	5. 4	6. 4	7. 6	8. 0	7. 0	7. 3	5. 8

[1] See table 14, footnote 1.
[2] See table 14, footnote 2.
**Indicates significance at 1-percent level.

TABLE 17.—*Mean squares from analyses of variance of 1960 and 1961 hay yields and for 2 years combined for Ames, Iowa*

Source of variation	d.f.	1960	1961	Years combined
Whole plots	215	----------	----------	0. 2628
Replications	5	0. 7723	1. 2772	1. 9067
Treatments:				
Unadjusted	35	. 5831	. 7186	1. 0565
Adjusted	35	. 4900**	. 6815**	. 9504**
Blocks	30	. 0952	. 1038	. 1527
Component a	15	. 0843	. 0970	. 1092
Component b	15	. 1061	. 1106	. 1962
Intrablock error	145	. 0279	. 0288	. 0373
Randomized block error (a)	175	. 0395	. 0417	. 0571
Years	1	----------	----------	188. 4036**
Years × treatments	35	----------	----------	. 2452**
Randomized block error (b)	180	----------	----------	. 0273
Effective error	----	. 0319	. 0330	. 0430
μ[1]	----	. 0547	. 0563	. 0593
Relative efficiency (percent)	----	124	126	133
Coefficient of variation (percent)	----	3. 9	5. 5	5. 3

[1] See table 14, footnote 2.
**Indicates significance at 1-percent level.

Locations Combined

Mean squares from the combined analysis of variance over all locations except Iowa are given in table 18. The combined analysis was calculated with and without Lahontan and its crosses and mixtures, since some winter killing of this variety occurred in Minnesota and Wisconsin. When Lahontan and its crosses and mixtures were retained in the analysis, mean squares for treatments and the T×Y×L interaction were highly significant, and the T×L interaction was significant at the 5-percent level. All mean squares were highly significant when Lahontan and its crosses and mixtures were removed from the analysis.

TABLE 18.—*Mean squares and mean square expectations of interest from combined analysis of variance of seasonal hay yields with and without Lahontan and its crosses and mixtures for all locations except Iowa*

Source of variation	With Lahontan		Without Lahontan		Mean square expectations [1]
	d.f.	m.s.	d.f.	m.s.	
Years (Y)	1	40. 0477**	1	26. 7493**	----------
Locations (L)	7	76. 1990**	7	59. 7850**	----------
Y×L	7	32. 4141**	7	26. 2274**	----------
Treatments (T)	35	1. 0153**	27	. 6306**	$\sigma_e^2+\sigma_{TYL}^2+t\sigma_{TL}^2+\sigma_{TY}^2+ly\sigma_T^2$
T×Y	35	. 1281	27	. 1344**	$\sigma_e^2+\sigma_{TYL}^2+\sigma_{TY}^2$
T×L	245	. 1377*	189	. 1289**	$\sigma_e^2+\sigma_{TYL}^2+y\sigma_{TL}^2$
T×Y×L	245	. 1056**	189	. 0246**	$\sigma_e^2+\sigma_{TYL}^2$
Error (e)	2, 240	. 0141	[2] 2, 240	[2] . 0141	σ_e^2

[1] Source of variation for each σ^2 is indicated by subscript.
[2] Taken from combined analysis including Lahontan.
* and ** Indicate significance at 5- and 1-percent levels, respectively.

Crosses Versus Mixtures Versus Parent Varieties

The principal standards of comparison for crosses and mixtures were the high-parent and midparent (parent average) values. For the 11 combinations, the relative performance of variety crosses and mixtures was compared.[9]

Within Locations

1. None of the mixtures yielded significantly more than the corresponding high component variety, but the following three crosses yielded more than their corresponding high parents:

Variety crosses
INDIANA (table 4)
Narragansett × Williamsburg*
Narragansett × Culver*
NORTH CAROLINA (table 10)
Narragansett × Williamsburg*

2. Numerous crosses and mixtures[10] yielded more than their corresponding midparent values as follows:

Variety crosses	*Mixtures*
INDIANA (table 4)	
Atlantic × Rambler**	Atlantic and Rambler**
Narragansett × Williamsburg*	----------
Vernal × Lahontan*	----------
Vernal × Rambler*	Vernal and Rambler**
Narragansett × Culver**	----------
IOWA (table 5)	
Atlantic × Rambler**	Atlantic and Rambler**
Vernal × Lahontan**	----------
Vernal × Rambler**	Vernal and Rambler**

Variety crosses	*Mixtures*
KANSAS (table 6)	
----------	Atlantic and Narragansett**
Atlantic × Rambler**	Atlantic and Rambler**
----------	Atlantic and Vernal**
Narragansett × Williamsburg**	Narragansett and Williamsburg**
Vernal × Ranger**	----------
Vernal × Rambler**	Vernal and Rambler**
Vernal × Williamsburg**	----------
MINNESOTA (table 7)	
Atlantic × Lahontan**	Atlantic and Lahontan**
----------	Atlantic and Narragansett**
Buffalo × Lahontan**	Buffalo and Lahontan**
Vernal × Lahontan**	Vernal and Lahontan**
----------	Vernal and Williamsburg*
Narragansett × Culver*	----------
NEBRASKA (table 8)	
Atlantic × Lahontan*	----------
----------	Atlantic and Rambler*
Buffalo × Lahontan**	----------
Vernal × Lahontan*	----------
Vernal × Rambler*	Vernal and Rambler*
Vernal × Culver*	----------
NEW YORK (table 9)	
----------	Atlantic and Lahontan**
Atlantic × Rambler**	----------
----------	Buffalo and Lahontan*
Narragansett × Williamsburg*	----------
Vernal × Lahontan**	Vernal and Lahontan**
Buffalo × Culver*	----------
NORTH CAROLINA (table 10)	
Atlantic × Rambler**	Atlantic and Rambler**
Narragansett × Williamsburg*	----------
Vernal × Lahontan**	----------
Vernal × Rambler**	Vernal and Rambler**
Atlantic × Culver*	----------
PENNSYLVANIA (table 11)	
----------	Atlantic and Lahontan*
Atlantic × Rambler**	Atlantic and Rambler*
WISCONSIN (table 12)	
----------	Atlantic and Rambler*
Buffalo × Lahontan*	----------
Vernal × Lahontan**	Vernal and Lahontan*
Vernal × Rambler*	Vernal and Rambler**

[9] * and ** Indicate comparison is significant at 5- and 1-percent levels, respectively.
[10] Crosses and corresponding mixtures are paired when both are listed.

3. None of the crosses yielded significantly less than the corresponding midparent values, but the following three mixtures yielded less than the corresponding midparent values:

Mixtures

Iowa (table 5)

Vernal and Lahontan**
Vernal and Ranger*

Kansas (table 6)

Atlantic and Buffalo**

4. Crosses and their corresponding mixtures were not different in yield except as follows:

Cross > mixture	*Mixture > cross*
Indiana (table 4)	
Vernal × Lahontan**	----------
Iowa (table 5)	
Vernal × Lahontan**	Atlantic and Buffalo*
Vernal × Ranger*	----------
Kansas (table 6)	
Vernal × Williamsburg**	Atlantic and Narragansett*
----------	Atlantic and Vernal*
Nebraska (table 8)	
Atlantic × Lahontan*	----------
Buffalo × Lahontan*	----------
Vernal × Lahontan**	----------
New York (table 9)	
Narragansett × Williamsburg*	Atlantic and Lahontan**
North Carolina (table 10)	
Vernal × Lahontan**	----------
Wisconsin (table 12)	
----------	Narragansett and Williamsburg*

Locations Combined

1. Average yields of all crosses and of all mixtures over locations were significantly less than the average high-parent value, but significantly greater, at the 1-percent level, than the average midparent value (bottom of table 13). For individual combinations, the cross and the mixture of Narragansett with Williamsburg exceeded the high parent at 1- and 5-percent levels, respectively (table 20). Also, the cross of Narragansett with Culver exceeded its high parent at the 5-percent level. The three entries yielded 4, 2, and 2 percent more than their corresponding high parents, respectively.

2. The following crosses and mixtures yielded more than their respective midparent values (table 13):

Crosses	*Mixtures*
Atlantic × Lahontan**	Atlantic and Lahontan**
----------	Atlantic and Narragansett**
Atlantic × Rambler**	Atlantic and Rambler**
----------	Atlantic and Vernal*
Buffalo × Lahontan**	Buffalo and Lahontan**
Narragansett × Williamsburg**	Narragansett and Williamsburg**
Vernal × Lahontan**	Vernal and Lahontan**
Vernal × Rambler**	Vernal and Rambler**
Vernal × Williamsburg**	----------
Atlantic × Culver*	----------
Buffalo × Culver*	----------
Narragansett × Culver**	----------
Vernal × Culver**	----------

3. None of the crosses or mixtures yielded significantly less than its corresponding midparent value.

4. The average yield of 11 crosses did not differ from the average yield of the 11 corresponding mixtures. Within combinations, the following differences between crosses and mixtures occurred:

Cross > mixture	*Mixture > cross*
Vernal × Lahontan**	Atlantic and Narragansett*
----------	Atlantic and Vernal**

Variance Components

When Lahontan and its crosses and mixtures were retained in the combined analysis of variance over all locations except Iowa, the largest estimated variance component was σ^2_{TYL} followed by σ^2_l, as shown in table 19. The largest estimated variance component was σ^2_{TL} followed by σ^2_T when Lahontan and its crosses and mixtures were removed.

Table 19.—*Estimates of variance components from combined analysis of variance of 2-year seasonal hay yields from all locations except Iowa*

Component	With Lahontan	Without Lahontan
σ^2_T	0. 0534	0. 0245
σ^2_{TY}	. 0028	. 0137
σ^2_{TL}	. 0160	. 0522
σ^2_{TYL}	. 0915	. 0105
σ^2_e	. 0141	. 0141

Concomitant Information on Varieties and Crosses

Data for seedling vigor, spring growth, fall growth, recovery after first cut, stand, and winter injury by location are shown in tables 30 and 31 in the appendix. Differences between entries were significant for all these characters at each location where they were measured. The data are included for purposes of additional characterization of the varieties.

Discussion

The average yields of 11 crosses and corresponding mixtures, excluding Iowa data, were 104 and 103 percent, respectively, of the average midparent value, as shown in table 20. Crosses and mixtures each averaged 97 percent of the average high-parent value. Statistically each of the foregoing deviations from midparent or high-parent value was highly significant (table 13). Thus, the average performances of crosses and mixtures were (1) very similar and (2) about intermediate between the midparent and high-parent values (tables 13 and 20). That is to say, under the conditions sampled at the eight locations used in the combined analysis, crosses and mixtures performed better on the average than the average of parent varieties, but not as well as the average performance of better parent varieties in the individual combinations.

TABLE 20.—*Average hay yields of variety crosses and mixtures in percentage of respective high-parent and midparent values over all locations except Iowa*

Variety combination	Yield as compared with—			
	High parent [1]		Midparent [2]	
	Cross	Mixture	Cross	Mixture
	Percent	*Percent*	*Percent*	*Percent*
Atlantic × Buffalo	98	97	100	99
Atlantic × Lahontan	92	92	104**	105**
Atlantic × Narragansett	98	100	101	103**+
Atlantic × Rambler	97	97	109**	109**
Atlantic × Vernal	97	100	99	102*++
Buffalo × Lahontan	95	93	106**+	104**
Narragansett × Williamsburg	104**	102*	104**	103**
Vernal × Lahontan	97	94	109**++	105**
Vernal × Ranger	99	98	101	100
Vernal × Rambler	96	97	106**	108**
Vernal × Williamsburg	101	100	103**+	101
Atlantic × Culver	98	------	102*	----------
Buffalo × Culver	100	------	102*	----------
Narragansett × Culver	102*	------	103**	----------
Vernal × Culver	100	------	102**	----------
Average: Without Culver combinations	97	97	104**	103**
With Culver combinations	98	------	104**	----------

[1] * and ** Greater than high-parent value at 5- and 1-percent levels, respectively.

[2] * and ** Greater than midparent value at 5- and 1-percent levels, respectively. + and ++ Greater than corresponding mixture or cross at 5- and 1-percent levels, respectively.

A summary of the average performance of each variety combination over locations in percentage of respective high-parent and midparent values is also shown in table 20. Two comparisons are noteworthy: (1) Performance of crosses and mixtures was similar for the respective variety combinations and (2) the greatest increases over midparent yield were obtained with combinations involving Lahontan or Rambler. These two varieties were also the poorest adapted varieties in the tests and had the poorest stands (table 31). At individual locations they ranked from seventh to ninth in yield among nine varieties (tables 21–29).

Over locations, crosses yielded more than mixtures in three combinations—Buffalo × Lahontan, Vernal × Lahontan, and Vernal × Williamsburg—and mixtures yielded more than crosses in two combinations—Atlantic and Narragansett, and Atlantic and Vernal (table 20). The mixtures are considered first, since the crosses contained some seed equivalent to mixing of parent varieties.

Yield of Variety Mixtures

At individual locations, none of the variety mixtures yielded significantly more than the corresponding high-yielding component variety. When locations were combined, only the mixture Narragansett and Williamsburg outyielded the high component variety. At individual locations, mixtures often exceeded yields of respective midparent values. In the combined analysis, 8 of the 11 mixtures yielded significantly more than the average of component varieties. Two of the three remaining mixtures equaled or numerically exceeded midparent values. Only the mixture of Atlantic and Buffalo yielded numerically less than the average of the component varieties, but the difference was not significant.

The similar performance of variety crosses and variety mixtures and the superior yield of mixtures and crosses over midparent values seem best explained by competition within heterogeneous populations. Presumably the more vigorous plants of a mixture predominated in broadcast or drilled-row competition and gave a plot performance greater than the expected average for individual varieties in a mixture. Some experi-

mental evidence for the presumed competitive effects was obtained from the studies of Tysdal and Kiesselbach (*18*). A mixture of 75-percent Ladak seed and 25-percent selfed seed yielded more than the average of the components grown in separate plots. Results with alfalfa reported here also agree with those with pearl millet (*3*), small grains (*10*), soybeans (*14*), and beans (*1*).

Yield of Variety Crosses

Over locations Vernal × Lahontan yielded significantly more than its corresponding mixture (table 20). Conversely, the following mixtures yielded more than their corresponding crosses: Atlantic and Narragansett, and Atlantic and Vernal. Thus, with the possible exception of the cross Vernal × Lahontan, the average performance of crosses and mixtures over locations and years was very similar for all practical purposes. For that reason, competition among unlike individuals or complementary use of the environment appeared to be much more important than heterosis in explaining the superiority of crosses over midparent values.

The 15 variety crosses were evaluated at each of nine locations. In these tests only 3 variety crosses of a possible 135 comparisons yielded significantly more than the respective higher yielding parental variety of each combination. Narragansett × Williamsburg yielded significantly more than the higher yielding parent at two locations, and Narragansett × Culver was superior to the better parent at one location. These crosses exhibited possible heterosis, but the magnitude of their superiority was hardly sufficient to excite the alfalfa breeder.

Early data obtained by crossing corn varieties were summarized by Hayes and Garber (*9*). Of 157 corn variety crosses, each studied at 1 of 12 locations, 53 percent yielded more than the respective high-yielding parent. The average yield increase of variety crosses over the respective higher yielding parent corn varieties was 4.2 percent. Pollak et al. (*13*) reported that the F_1 populations of three corn variety crosses yielded 9 to 20 percent more than midparent values.

Studies of corn and alfalfa, however, are not entirely comparable. Cross-pollination in corn was under complete control, whereas in variety crosses of alfalfa used in the study reported here, it was assumed that less than half of the seed resulted from cross-pollination between varieties. Furthermore, it is assumed that there was less competition among individual genotypes of corn than among genotypes of alfalfa. Differences in pollination and plant competition probably account for the divergence in results obtained for variety crosses in corn and alfalfa.

The performance of alfalfa variety crosses under natural conditions in the field may deviate from the performance indicated in this study for three reasons; namely, (1) a different amount of self-pollination may occur in cages than under natural conditions, (2) climatic conditions and kind of pollination may affect the amount of self-pollination, and (3) variety crosses produced by interplanting equal quantities of seed of the parents, unless the seed from the parents is harvested separately, will likely consist of unequal contributions by the parents, since varieties differ in seed production. Such possible differences, however, should not be sufficient to invalidate the conclusion that the alfalfa variety crosses in this study are not likely to give rise immediately to new strains that will materially surpass the performance of the best variety available for a particular area. Investigation of intravarietal and intervarietal clonal crosses is suggested if further study of heterosis in variety crosses is undertaken.

Summary

In 2-year yield tests 15 alfalfa variety crosses, 11 of the comparable 50 : 50 mixtures of pairs of varieties, 9 parent varieties, and a mass polycross entry were grown in a 6-by-6 triple lattice design in Indiana, Iowa, Kansas, Minnesota, Nebraska, New York, North Carolina, and Pennsylvania. The same entries were grown in a randomized block design in Wisconsin. Data were analyzed by locations and for all locations combined except Iowa.

Variety crosses were produced by compositing equal quantities of seed from pairs of varieties that were bee pollinated under screen cage. The variety crosses were assumed to consist of about 10-percent selfed seed, 45-percent varietal hybrid seed, and 45-percent parent variety seed.

Yield of variety crosses was similar to that of corresponding variety mixtures. Variety mixtures and variety crosses averaged 103 and 104 percent, respectively, of the midparent yield. Variety crosses and variety mixtures yielded only 97 percent as much as the high-parent average of respective crosses and mixtures. Crosses or mixtures giving greatest yield advantage over midparent generally had one of the poorer yielding varieties as one parent or component. The similar performance of variety crosses and variety mixtures and the superior yield of mixtures and crosses over midparent values seem best explained by competition within heterogeneous populations. Presumably the more vigorous plants of a mixture predominated in broadcast or drilled-row competition and gave a plot performance greater than

the expected average for individual varieties in a mixture.

The crosses Narragansett × Williamsburg and Narragansett × Culver yielded 4 and 2 percent more than the respective high parents. The mixture of Narragansett and Williamsburg yielded 2 percent more than the high parent. (The mixture of Narragansett and Culver was not included in the study.) Investigation of intravarietal and intervarietal clonal crosses is suggested if further study of heterosis in variety crosses is undertaken.

It was concluded that neither the alfalfa variety crosses nor variety mixtures in this study would contribute substantially to increasing the yield over the highest yielding variety at a particular location.

Relative efficiency of the lattice design as compared with the randomized block design ranged from 112 percent at Kansas to 174 percent at Pennsylvania for the combined 1959 and 1960 seasonal yields.

Estimated variance components for treatments and the interaction of treatments with locations and years were calculated for the combined data from eight locations with and without Lahontan and its crosses and mixtures. Estimated components of variance were greatest for the treatment × year × location interaction and for treatments with Lahontan. When Lahontan entries were excluded from the analysis, the estimated variance components were largest for treatments × locations and for treatments.

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Appendix

TABLE 21.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Lafayette, Ind.*[1]

Entries	1959 cuttings				1960 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	2. 44 b–g	0. 80 c–f	0. 65 b–f	3. 85 c–f	3. 09 e–i	1. 64 e–h	1. 21 mn	6. 01 hij	4. 96 ijk
Atlantic × Lahontan	2. 18 a–e	. 80 c–f	. 65 b–f	3. 66 a–e	2. 93 b–h	1. 67 fgh	1. 08 f–l	5. 68 e–j	4. 65 d–k
Atlantic × Narragansett	2. 33 b–g	. 76 b–f	. 69 def	3. 79 b–f	3. 10 e–i	1. 54 b–h	1. 05 d–l	5. 68 e–j	4. 73 d–k
Atlantic × Rambler	2. 62 g	. 71 bcd	. 67 c–f	3. 96 c–f	3. 16 f–i	1. 52 b–h	. 95 b–f	5. 61 d–i	4. 82 e–k
Atlantic × Culver	2. 39 b–g	. 71 bcd	. 65 b–f	3. 77 b–f	3. 23 ghi	1. 55 b–h	1. 01 c–k	5. 78 f–j	4. 80 e–k
Atlantic × Vernal	2. 44 b–g	. 75 b–f	. 65 b–f	3. 84 c–f	3. 15 f–i	1. 56 b–h	. 99 c–i	5. 66 e–i	4. 75 d–k
Buffalo × Lahontan	2. 24 a–f	. 79 b–f	. 63 b–f	3. 63 a–e	2. 92 b–h	1. 56 b–h	1. 10 h–n	5. 57 c–h	4. 61 c–i
Buffalo × Culver	2. 21 a–f	. 68 b	. 66 c–f	3. 56 a–d	3. 07 e–i	1. 61 c–h	1. 16 lmn	5. 83 f–j	4. 66 d–k
Culver × Narragansett	2. 49 efg	. 78 b–f	. 69 def	4. 02 ef	3. 33 i	1. 41 bcd	1. 00 c–j	5. 72 e–j	4. 87 f–k
Culver × Vernal	2. 64 g	. 72 b–e	. 59 a–d	3. 90 c–f	3. 13 f–i	1. 39 bc	. 99 c–i	5. 54 c–h	4. 77 d–k
Lahontan × Vernal	2. 45 b–g	. 79 b–f	. 59 a–d	3. 82 b–f	2. 91 b–h	1. 60 c–h	. 96 b–g	5. 49 c–g	4. 68 d–k
Narragansett × Williamsburg	2. 31 b–g	. 83 ef	. 71 ef	3. 88 c–f	3. 05 d–i	1. 69 gh	1. 10 h–n	5. 79 f–j	4. 83 e–k
Ranger × Vernal	2. 39 b–g	. 78 b–f	. 71 ef	3. 84 c–f	3. 23 ghi	1. 43 b–e	1. 04 c–l	5. 73 e–j	4. 81 e–k
Vernal × Rambler	2. 53 fg	. 70 bc	. 60 b–e	3. 81 b–f	2. 90 b–g	1. 35 b	. 86 b	5. 11 bcd	4. 48 cde
Vernal × Williamsburg	2. 21 a–f	. 78 b–f	. 67 c–f	3. 68 a–e	2. 88 b–g	1. 55 b–h	1. 13 i–n	5. 60 d–h	4. 64 d–j
Mixtures:									
Atlantic and Buffalo	2. 48 d–g	. 76 b–f	. 68 c–f	3. 79 b–f	3. 26 hi	1. 73 h	1. 16 lmn	6. 17 j	5. 02 k
Atlantic and Lahontan	2. 28 b–g	. 78 b–f	. 59 a–d	3. 64 a–e	2. 65 ab	1. 61 c–h	. 99 c–i	5. 26 b–e	4. 46 cde
Atlantic and Narragansett	2. 42 b–g	. 84 f	. 68 c–f	3. 93 c–f	3. 06 e–i	1. 55 b–h	1. 09 g–m	5. 67 e–j	4. 82 e–k
Atlantic and Rambler	2. 47 c–g	. 79 b–f	. 68 c–f	3. 97 def	3. 20 f–i	1. 62 d–h	1. 07 e–l	5. 89 g–j	4. 90 g–k
Atlantic and Vernal	2. 61 g	. 79 b–f	. 67 c–f	4. 12 f	3. 15 f–i	1. 62 d–h	1. 04 c–l	5. 80 f–j	4. 95 h–k
Buffalo and Lahontan	2. 13 abc	. 79 b–f	. 64 b–f	3. 54 abc	2. 69 abc	1. 54 b–h	1. 06 d–l	5. 25 b–e	4. 41 cd
Lahontan and Vernal	2. 12 ab	. 80 c–f	. 61 b–f	3. 58 a–d	2. 65 ab	1. 43 b–e	. 94 b–e	5. 07 bc	4. 27 b
Narragansett and Williamsburg	2. 15 a–d	. 79 b–f	. 64 b–f	3. 59 a–d	3. 04 d–i	1. 50 b–g	1. 04 c–l	5. 55 c–h	4. 58 c–h
Ranger and Vernal	2. 35 b–g	. 78 b–f	. 61 b–f	3. 80 b–f	3. 01 c–i	1. 47 b–g	. 94 b–e	5. 41 c–g	4. 60 c–i
Vernal and Rambler	2. 52 fg	. 73 b–e	. 58 a–d	3. 80 b–f	2. 97 b–h	1. 45 b–f	. 94 b–e	5. 36 c–f	4. 59 c–i
Vernal and Williamsburg	2. 40 b–g	. 78 b–f	. 67 c–f	3. 86 c–f	2. 95 b–h	1. 62 d–h	1. 12 i–n	5. 68 e–j	4. 76 d–k
Parent varieties:									
Atlantic	2. 48 d–g	. 82 def	. 68 c–f	4. 03 ef	3. 35 i	1. 63 d–h	1. 14 k–n	6. 11 i–j	5. 01 jk
Buffalo	2. 27 b–g	. 82 def	. 72 f	3. 82 b–f	2. 86 b–f	1. 58 c–h	1. 22 n	5. 67 e–j	4. 75 d–k
Culver	2. 33 b–g	. 75 b–f	. 64 b–f	3. 72 a–f	2. 96 b–h	1. 52 b–h	. 93 bcd	5. 38 c–g	4. 55 c–g
Lahontan	1. 94 a	. 82 def	. 55 ab	3. 33 a	2. 43 a	1. 52 b–h	. 91 bc	4. 84 b	4. 07 b
Narragansett	2. 37 b–g	. 70 bc	. 66 c–f	3. 75 b–f	2. 92 b–h	1. 41 bcd	. 91 bc	5. 27 b–e	4. 48 cde
Rambler	2. 41 b–g	. 54 a	. 50 a	3. 41 ab	2. 44 a	1. 02 a	. 60 a	4. 08 a	3. 76 a
Ranger	2. 29 b–g	. 79 b–f	. 65 b–f	3. 74 a–f	2. 88 b–g	1. 48 b–g	. 99 c–i	5. 37 c–f	4. 53 c–g
Vernal	2. 49 efg	. 73 b–e	. 67 c–f	3. 84 c–f	3. 06 e–i	1. 46 b–f	. 95 b–f	5. 43 c–g	4. 66 d–k
Williamsburg	2. 20 a–f	. 80 c–f	. 67 c–f	3. 67 a–e	2. 70 a–d	1. 54 b–h	1. 11 i–n	5. 34 c–f	4. 52 c–f
Mass polycross	2. 43 b–g	. 68 b	. 57 abc	3. 68 a–e	2. 76 a–e	1. 50 b–g	. 97 b–h	5. 24 b–e	4. 46 cde

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 22.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Ames, Iowa* [1]

Entries	1960 cuttings				1961 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	2. 10 ef	1. 47 k–p	1. 08 c–i	4. 63 e–j	1. 46 f–i	1. 16 k–p	0. 91 k–n	3. 53 l–q	4. 08 i–n
Atlantic × Lahontan	1. 95 cd	1. 37 e–j	. 01 abc	4. 25 c	1. 35 c–f	1. 03 c–i	. 77 c–i	3. 14 d–i	3. 70 c–f
Atlantic × Narragansett	2. 33 j–m	1. 51 m–p	1. 10 e–i	4. 91 klm	1. 62 lm	1. 20 opq	. 79 d–j	3. 62 n–q	4. 26 mn
Atlantic × Rambler	2. 31 i–l	1. 41 f–l	. 98 b–g	4. 74 e–m	1. 46 f–i	1. 09 f–m	. 77 c–i	3. 32 g–m	4. 03 g–m
Atlantic × Culver	2. 25 f–k	1. 42 g–m	. 97 b–g	4. 66 e–k	1. 50 h–l	1. 10 g–n	. 81 f–k	3. 42 i–o	4. 04 g–n
Atlantic × Vernal	2. 20 f–j	1. 47 k–p	1. 01 b–h	4. 67 e–k	1. 43 d–h	1. 07 d–k	. 71 b–f	3. 21 e–j	3. 94 e–l
Buffalo × Lahontan	1. 85 bc	1. 36 d–i	1. 00 b–h	4. 17 bc	1. 30 e	1. 02 c–h	. 81 f–k	3. 13 d–h	3. 64 c
Buffalo × Culver	2. 13 efg	1. 47 k–p	1. 09 d–i	4. 67 e–k	1. 46 f–i	1. 16 j–p	. 85 i–m	3. 46 j–p	4. 06 h–n
Culver × Narragansett	2. 42 lmn	1. 49 l–p	1. 00 b–h	4. 94 lm	1. 53 h–m	1. 10 g–n	. 76 c–i	3. 39 h–n	4. 16 j–n
Culver × Vernal	2. 43 l–o	1. 45 i–o	. 94 a–f	4. 80 g–m	1. 44 e–i	1. 04 d–i	. 69 bcd	3. 16 d–i	3. 98 f–m
Lahontan × Vernal	2. 17 f–i	1. 43 g–n	. 94 a–f	4. 53 ef	1. 32 cde	1. 06 d–i	. 78 d–j	3. 16 d–i	3. 85 c–i
Narragansett × Williamsburg	2. 23 f–j	1. 52 nop	1. 14 ghi	4. 90 klm	1. 59 j–m	1. 23 pq	. 92 lmn	3. 75 q	4. 33 n
Ranger × Vernal	2. 30 h–l	1. 49 l–p	1. 00 b–h	4. 78 g–m	1. 28 c	1. 01 e–g	. 80 d–j	3. 08 d–g	3. 93 d–k
Vernal × Rambler	2. 56 o	1. 37 e–j	. 92 a–d	4. 86 j–m	1. 30 c	. 98 bcd	. 63 b	2. 92 bcd	3. 89 e–j
Vernal × Williamsburg	2. 26 g–k	1. 53 op	1. 11 f–i	4. 91 klm	1. 45 f–i	1. 18 m–g	. 91 k–n	3. 55 m–q	4. 23 lmn
Mixtures:									
Atlantic and Buffalo	2. 20 f–j	1. 52 nop	1. 10 e–i	4. 85 i–m	1. 56 i–m	1. 19 n–q	. 91 k–n	3. 67 n–q	4. 26 mn
Atlantic and Lahontan	1. 88 bcd	1. 35 d–h	. 98 b–g	4. 17 bc	1. 43 d–h	1. 06 d–j	. 75 c–h	3. 24 e–k	3. 70 c–f
Atlantic and Narragansett	2. 34 j–m	1. 48 l–p	1. 00 b–h	4. 82 h–m	1. 52 h–m	1. 16 k–p	. 81 e–k	3. 49 k–q	4. 16 j–n
Atlantic and Rambler	2. 24 f–k	1. 40 e–l	. 99 b–g	4. 66 e–k	1. 49 h–k	1. 12 i–o	. 85 i–m	3. 46 j–p	4. 06 h–n
Atlantic and Vernal	2. 29 h–l	1. 46 j–p	1. 01 b–h	4. 77 f–m	1. 51 h–m	1. 11 h–o	. 79 d–j	3. 41 i–o	4. 09 i–n
Buffalo and Lahontan	1. 81 b	1. 34 d–g	. 97 b–g	4. 17 bc	1. 31 cd	1. 09 f–m	. 78 d–i	3. 18 d–j	3. 68 cde
Lahontan and Vernal	1. 93 bcd	1. 28 cd	. 92 a–d	4. 10 bc	1. 13 b	. 90 b	. 67 bc	2. 69 b	3. 39 b
Narragansett and Williamsburg	2. 15 fgh	1. 45 i–o	1. 08 c–i	4. 70 e–l	1. 53 h–m	1. 21 pq	. 94 lmn	3. 68 opq	4. 19 k–n
Ranger and Vernal	2. 22 f–j	1. 38 e–k	. 97 b–g	4. 56 efg	1. 28 c	. 99 cde	. 70 b–e	2. 96 cde	3. 76 c–g
Vernal and Rambler	2. 46 mno	1. 32 c–f	. 93 a–e	4. 70 e–l	1. 35 c–g	. 94 bc	. 73 a–g	3. 03 c–f	3. 86 c–i
Vernal and Williamsburg	2. 17 f–i	1. 48 l–p	1. 10 e–i	4. 75 f–m	1. 45 f–i	1. 10 g–n	. 85 h–m	3. 40 h–o	4. 07 h–n
Parent varieties:									
Atlantic	2. 21 f–j	1. 55 p	1. 11 f–i	4. 83 h–m	1. 64 m	1. 19 n–q	. 89 j–n	3. 72 pq	4. 27 mn
Buffalo	2. 01 de	1. 42 g–m	1. 20 i	4. 59 e–h	1. 48 g–k	1. 17 l–q	. 95 mn	3. 59 m–q	4. 09 i–n
Culver	2. 35 j–m	1. 31 cde	. 91 abc	4. 60 e–i	1. 46 f–j	1. 02 c–i	. 75 c–i	3. 25 e–k	3. 93 d–k
Lahontan	1. 56 a	1. 19 b	. 85 ab	3. 62 a	1. 15 b	. 94 bc	. 71 b–f	2. 80 bc	3. 21 ab
Narragansett	2. 38 klm	1. 48 l–p	1. 04 c–i	4. 91 klm	1. 60 klm	1. 18 m–q	. 83 g–l	3. 61 n–q	4. 26 mn
Rambler	2. 23 f–j	1. 02 a	. 79 a	4. 01 b	. 85 a	. 59 a	. 53 a	1. 96 a	2. 98 a
Ranger	2. 16 f–i	1. 37 e–j	. 96 b–f	4. 50 de	1. 27 c	1. 01 c–g	. 78 c–i	3. 07 d–g	3. 79 c–h
Vernal	2. 52 no	1. 44 h–o	1. 03 e–i	4. 96 m	1. 44 e–i	1. 08 e–l	. 74 b–h	3. 25 f–l	4. 10 i–n
Williamsburg	2. 00 de	1. 48 l–p	1. 17 hi	4. 64 e–j	1. 53 h–m	1. 26 q	. 97 n	3. 75 q	4. 20 k–n
Mass polycross	2. 10 ef	1. 25 bc	. 91 abc	4. 30 cd	1. 28 c	1. 00 c–f	. 70 b–f	2. 99 c–f	3. 65 cd

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 23.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Manhattan, Kans.*[1]

Entries	1959 cuttings					1960 cuttings					2-year average
	1st	2d	3d	4th	Total	1st	2d	3d	4th	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:											
Atlantic × Buffalo	2. 11 g–l	2. 12 i–n	1. 61 m–p	1. 42 k–n	7. 15 i–o	2. 69 m–p	1. 76 g–k	1. 80 jk	1. 38 lmn	7. 69 l	7. 42 lm
Atlantic × Lahontan	2. 07 f–k	1. 96 d–i	1. 37 f–i	1. 32 h–l	6. 71 f–j	2. 51 h–n	1. 73 f–k	1. 61 e–h	1. 16 def	7. 03 ghi	6. 86 g–k
Atlantic × Narragansett	2. 21 k–o	2. 08 g–n	1. 48 h–m	1. 25 f–i	7. 00 h–o	2. 58 i–p	1. 66 f–h	1. 59 efg	1. 18 efg	7. 03 ghi	7. 02 i–l
Atlantic × Rambler	2. 26 l–o	2. 09 g–n	1. 46 h–l	1. 46 mno	7. 06 h–o	2. 60 j–p	1. 70 f–i	1. 63 e–i	1. 18 efg	7. 12 hij	7. 08 i–l
Atlantic × Culver	2. 29 no	2. 23 mn	1. 57 k–p	1. 31 g–l	7. 43 mno	2. 64 l–p	1. 76 g–k	1. 67 f–k	1. 19 e–h	7. 26 h–l	7. 34 klm
Atlantic × Vernal	2. 14 i–n	2. 00 e–j	1. 49 i–n	1. 31 g–l	6. 92 g–m	2. 55 h–o	1. 70 f–i	1. 66 f–j	1. 21 e–j	7. 15 h–k	7. 03 i–l
Buffalo × Lahontan	1. 90 bcd	1. 98 d–j	1. 43 g–j	1. 40 k–n	6. 75 f–k	2. 49 g–m	1. 72 f–j	1. 62 e–h	1. 21 e–j	6. 99 ghi	6. 87 g–k
Buffalo × Culver	2. 11 g–l	2. 15 j–n	1. 55 j–p	1. 44 l–o	7. 23 j–o	2. 60 j–p	1. 70 f–i	1. 73 f–k	1. 33 k–n	7. 37 h–l	7. 30 j–m
Culver × Narragansett	2. 12 h–m	2. 02 f–k	1. 31 efg	1. 18 efg	6. 65 f–i	2. 39 d–j	1. 47 bc	1. 36 bcd	1. 05 bc	6. 29 cde	6. 47 e–h
Culver × Vernal	2. 17 j–o	1. 98 d–j	1. 28 def	1. 07 cde	6. 55 e–h	2. 42 e–k	1. 52 cde	1. 36 bcd	1. 05 bc	6. 34 cde	6. 43 d–g
Lahontan × Vernal	1. 91 b–e	1. 81 bcd	1. 22 cde	1. 18 efg	6. 04 bcd	2. 28 c–f	1. 61 def	1. 48 cde	1. 07 bcd	6. 47 def	6. 25 c–f
Narragansett × Williamsburg	2. 04 e–j	2. 09 g–n	1. 48 h–m	1. 38 i–n	7. 00 h–n	2. 41 d–j	1. 71 f–i	1. 73 f–k	1. 31 i–m	7. 14 h–k	7. 08 i–l
Ranger × Vernal	2. 00 d–i	2. 04 f–l	1. 31 efg	1. 27 f–j	6. 63 f–i	2. 55 h–o	1. 66 fgh	1. 59 efg	1. 20 e–i	6. 98 ghi	6. 82 g–j
Vernal × Rambler	1. 88 bcd	1. 74 b	1. 08 b	. 93 b	5. 66 b	2. 21 b–d	1. 39 b	1. 26 b	. 98 b	5. 77 b	5. 73 b
Vernal × Williamsburg	2. 06 f–k	2. 10 h–n	1. 64 op	1. 46 mno	7. 27 c–f	2. 63 k–p	1. 84 jk	1. 83 k	1. 40 mn	7. 70 l	7. 48 lm
Mixtures:											
Atlantic and Buffalo	2. 12 h–m	2. 13 i–n	1. 56 j–p	1. 40 j–n	7. 16 i–o	2. 60 j–p	1. 69 f–i	1. 71 f–k	1. 28 g–l	7. 30 h–l	7. 23 i–m
Atlantic and Lahontan	2. 11 g–l	2. 09 g–n	1. 44 g–k	1. 35 h–n	6. 97 g–n	2. 38 d–i	1. 75 g–k	1. 59 efg	1. 11 cde	6. 84 fgh	6. 89 g–k
Atlantic and Narragansett	2. 27 mno	2. 19 k–n	1. 59 l–p	1. 38 i–n	7. 40 l–o	2. 71 nop	1. 79 h–k	1. 73 f–k	1. 24 f–k	7. 48 i–l	7. 44 lm
Atlantic and Rambler	2. 25 l–o	2. 15 j–n	1. 50 i–n	1. 30 g–k	7. 25 j–o	2. 75 op	1. 76 g–k	1. 68 f–k	1. 20 e–i	7. 33 h–l	7. 30 j–m
Atlantic and Vernal	2. 25 l–o	2. 13 i–n	1. 58 l–p	1. 37 i–n	7. 27 k–o	2. 70 nop	1. 81 ijk	1. 75 g–k	1. 30 h–m	7. 58 jkl	7. 43 lm
Buffalo and Lahontan	1. 72 a	2. 04 f–k	1. 51 j–o	1. 44 l–o	6. 83 g–k	2. 46 f–l	1. 75 g–k	1. 71 f–k	1. 22 e–j	7. 18 h–l	7. 00 i–l
Lahontan and Vernal	1. 81 abc	1. 93 c–h	1. 22 cde	1. 16 ef	6. 08 b–e	2. 11 bc	1. 63 efg	1. 50 de	1. 00 b	6. 25 b–e	6. 16 b–f
Narragansett and Williamsburg	1. 96 c–g	2. 05 f–m	1. 54 j–o	1. 36 h–n	6. 89 g–m	2. 47 f–l	1. 70 f–i	1. 75 g–k	1. 32 j–n	7. 27 h–l	7. 07 i–l
Ranger and Vernal	2. 00 d–i	1. 91 b–g	1. 32 efg	1. 23 fgh	6. 44 d–g	2. 36 d–h	1. 53 cde	1. 49 de	1. 13 c–f	6. 54 efg	6. 48 e–h
Vernal and Rambler	1. 92 b–e	1. 88 b–f	1. 17 bcd	. 93 b	5. 97 bcd	2. 29 c–g	1. 42 bc	1. 33 bc	1. 00 b	5. 98 bcd	5. 99 bcd
Vernal and Williamsburg	1. 95 c–f	1. 97 d–j	1. 44 g–k	1. 33 h–m	6. 68 f–i	2. 48 f–l	1. 64 efg	1. 71 f–k	1. 31 i–m	7. 17 h–l	6. 92 h–k
Parent varieties:											
Atlantic	2. 30 o	2. 21 lmn	1. 62 nop	1. 42 k–o	7. 58 o	2. 76 p	1. 85 k	1. 79 ijk	1. 29 g–l	7. 66 kl	7. 64 m
Buffalo	2. 07 f–k	2. 25 n	1. 66 p	1. 55 o	7. 50 no	2. 67 l–p	1. 73 f–k	1. 83 k	1. 42 n	7. 66 kl	7. 58 m
Culver	2. 23 l–o	2. 09 g–n	1. 29 def	1. 14 def	6. 86 g–l	2. 47 f–l	1. 46 bc	1. 28 b	1. 04 bc	6. 16 b–e	6. 53 fgh
Lahontan	1. 78 ab	1. 77 bc	1. 27 def	1. 23 fgh	6. 01 bcd	2. 11 bc	1. 64 efg	1. 50 de	1. 03 bc	6. 32 cde	6. 16 b–f
Narragansett	1. 97 d–h	1. 94 c–h	1. 32 efg	1. 23 fgh	6. 28 c–f	2. 22 b–e	1. 48 bc	1. 38 bcd	1. 05 bc	6. 10 b–e	6. 20 c–f
Rambler	1. 72 a	1. 40 a	. 75 a	. 58 a	4. 50 a	1. 61 a	. 98 a	. 86 a	. 62 a	4. 03 a	4. 28 a
Ranger	2. 02 d–j	1. 96 d–i	1. 35 e–h	1. 32 h–l	6. 66 b	2. 53 h–n	1. 66 fgh	1. 58 ef	1. 20 e–i	6. 94 f–i	6. 80 ghi
Vernal	1. 91 b–e	1. 83 b–e	1. 17 bcd	. 99 bc	5. 97 bcd	2. 38 d–i	1. 51 bcd	1. 33 bc	. 98 b	6. 15 b–e	6. 06 b–e
Williamsburg	1. 89 bcd	2. 05 f–m	1. 58 l–p	1. 48 no	6. 94 g–m	2. 55 h–o	1. 74 f–k	1. 76 hij	1. 37 lmn	7. 47 i–l	7. 19 i–m
Mass polycross	1. 83 abc	1. 74 b	1. 14 bc	1. 03 bcd	5. 80 bc	2. 08 b	1. 42 bc	1. 38 bcd	1. 03 bc	5. 86 bc	5. 82 bc

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 24.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Rosemount, Minn.*[1]

Entries	1959 cuttings				1960 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	1. 59 e–h	1. 49 b–e	1. 47 b–e	4. 54 def	1. 80 b–h	1. 62 bcd	1. 46 f–j	4. 89 def	4. 72 e–j
Atlantic × Lahontan	1. 20 bc	1. 45 bc	1. 47 b–e	4. 13 b	1. 74 b–g	1. 61 bcd	1. 40 c–i	4. 75 cde	4. 46 bcd
Atlantic × Narragansett	1. 75 h–m	1. 56 b–f	1. 46 bcd	4. 73 e–j	1. 82 d–h	1. 69 cd	1. 42 c–i	4. 93 def	4. 86 h–k
Atlantic × Rambler	1. 79 i–n	1. 53 b–f	1. 47 b–e	4. 80 e–j	1. 70 b–f	1. 61 bcd	1. 37 c–h	4. 68 cde	4. 73 c–j
Atlantic × Culver	1. 71 g–l	1. 61 b–f	1. 52 de	4. 83 f–j	1. 63 bcd	1. 67 bcd	1. 43 d–j	4. 73 cde	4. 77 f–k
Atlantic × Vernal	1. 72 g–l	1. 52 b–f	1. 42 bcd	4. 66 e–h	1. 74 b–g	1. 61 bcd	1. 38 c–i	4. 73 cde	4. 74 f–j
Buffalo × Lahontan	1. 07 b	1. 52 b–f	1. 48 cde	4. 04 b	1. 68 b–f	1. 62 bcd	1. 51 ij	4. 81 c–f	4. 49 b–e
Buffalo × Culver	1. 50 def	1. 50 b–e	1. 50 cde	4. 51 c–f	1. 77 b–g	1. 66 bcd	1. 49 hij	4. 92 def	4. 72 e–j
Culver × Narragansett	1. 88 l–n	1. 65 def	1. 51 cde	5. 07 j	1. 79 b–h	1. 65 bcd	1. 40 c–i	4. 84 c–f	4. 95 j–k
Culver × Vernal	1. 88 l–n	1. 62 c–f	1. 49 cde	5. 04 ij	1. 75 b–g	1. 67 bcd	1. 40 c–i	4. 83 c–f	4. 95 j–k
Lahontan × Vernal	1. 60 e–i	1. 53 b–f	1. 41 bc	4. 54 def	1. 79 b–h	1. 72 cd	1. 42 c–i	4. 93 def	4. 77 f–k
Narragansett × Williamsburg	1. 57 e–h	1. 58 b–f	1. 45 bcd	4. 58 def	1. 75 b–g	1. 62 bcd	1. 45 f–j	4. 82 c–f	4. 72 e–j
Ranger × Vernal	1. 73 g–l	1. 51 b–f	1. 39 bc	4. 58 def	1. 71 b–f	1. 66 bcd	1. 39 c–i	4. 77 c–f	4. 72 e–j
Vernal × Rambler	1. 97 n	1. 62 c–f	1. 39 bc	4. 99 g–j	1. 67 b–f	1. 69 cd	1. 30 cd	4. 65 cd	4. 90 ijk
Vernal × Williamsburg	1. 68 f–k	1. 56 b–f	1. 51 cde	4. 70 c–i	1. 74 b–g	1. 69 cd	1. 45 f–j	4. 88 def	4. 82 h–k
Mixtures:									
Atlantic and Buffalo	1. 61 e–i	1. 54 b–f	1. 50 cde	4. 69 e–i	1. 81 c–h	1. 73 d	1. 47 g–j	5. 01 ef	4. 81 h–k
Atlantic and Lahontan	1. 36 cd	1. 49 b–e	1. 44 bcd	4. 28 bcd	1. 82 d–h	1. 60 bcd	1. 41 c–i	4. 83 c–f	4. 55 c–g
Atlantic and Narragansett	1. 80 j–n	1. 62 c–f	1. 59 e	5. 01 hij	1. 98 h	1. 66 bcd	1. 46 f–j	5. 09 f	5. 02 k
Atlantic and Rambler	1. 72 g–l	1. 44 b	1. 48 cde	4. 65 cfg	1. 71 b–f	1. 65 bcd	1. 43 d–j	4. 78 c–f	4. 68 d–i
Atlantic and Vernal	1. 79 i–n	1. 58 b–f	1. 46 bcd	4. 85 f–j	1. 79 b–h	1. 68 bcd	1. 38 c–i	4. 86 def	4. 85 h–k
Buffalo and Lahontan	1. 26 c	1. 47 bc	1. 48 cde	4. 25 bcd	1. 61 b	1. 63 bcd	1. 44 c–j	4. 68 cde	4. 43 bc
Lahontan and Vernal	1. 69 g–l	1. 54 b–f	1. 46 bcd	4. 74 e–i	1. 80 b–h	1. 71 cd	1. 40 c–i	4. 90 def	4. 79 g–k
Narragansett and Williamsburg	1. 71 g–l	1. 54 b–f	1. 46 bcd	4. 70 e–i	1. 81 c–h	1. 63 bcd	1. 31 cde	4. 75 cde	4. 72 e–j
Ranger and Vernal	1. 83 j–n	1. 51 b–f	1. 49 cde	4. 86 f–j	1. 78 b–g	1. 63 bcd	1. 38 c–i	4. 78 c–f	4. 77 f–k
Vernal and Rambler	1. 93 mn	1. 68 f	1. 44 bcd	5. 02 ij	1. 81 c–h	1. 66 bcd	1. 34 c–g	4. 81 c–f	4. 93 ijk
Vernal and Williamsburg	1. 84 j–n	1. 56 b–f	1. 46 bcd	4. 85 f–j	1. 83 e–h	1. 64 bcd	1. 46 f–j	4. 93 def	4. 87 h–k
Parent varieties:									
Atlantic	1. 67 f–k	1. 55 b–f	1. 54 de	4. 73 e–j	1. 72 b–g	1. 61 bcd	1. 39 c–i	4. 72 cde	4. 73 e–j
Buffalo	1. 48 de	1. 48 bcd	1. 50 cde	4. 46 cde	1. 67 b–f	1. 63 bcd	1. 56 j	4. 86 def	4. 69 d–i
Culver	1. 72 g–l	1. 58 b–f	1. 51 cde	4. 86 f–j	1. 65 b–c	1. 67 bcd	1. 33 c–f	4. 64 cd	4. 69 d–i
Lahontan	. 22 a	. 45 a	. 70 d	1. 36 a	1. 08 a	1. 26 a	. 95 a	3. 29 a	2. 35 a
Narragansett	1. 94 mn	1. 62 c–f	1. 43 bcd	4. 47 cde	1. 86 fgh	1. 61 bcd	1. 29 c	4. 76 c–f	4. 84 h–k
Rambler	1. 86 k–n	1. 47 bc	1. 41 bc	4. 74 e–j	1. 61 b	1. 58 bc	1. 14 b	4. 33 b	4. 53 c–f
Ranger	1. 65 e–j	1. 45 bc	1. 35 b	4. 97 cde	1. 78 b–g	1. 63 bcd	1. 41 c–i	4. 82 c–f	4. 64 c–h
Vernal	1. 88 lmn	1. 66 ef	1. 48 cde	5. 02 ij	1. 91 gh	1. 65 bcd	1. 37 c–h	4. 93 def	5. 01 k
Williamsburg	1. 27 c	1. 44 b	1. 43 bcd	4. 18 bc	1. 62 bc	1. 54 b	1. 36 c–h	4. 51 bc	4. 30 b
Mass polycross	1. 55 efg	1. 49 b–e	1. 46 bcd	4. 51 c–f	1. 80 b–h	1. 70 cd	1. 37 c–h	4. 88 def	4. 71 e–j

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 25.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Lincoln, Nebr.*[1]

Entries	1959 cuttings			1960 cuttings				2-year average
	1st	2d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:								
Atlantic × Buffalo	0.91 b–i	1.27 e–i	2.17 e–k	2.45 c–h	1.66 d	1.38 h	5.52 fgh	3.87 gh
Atlantic × Lahontan	.91 b–i	1.07 ab	1.98 bc	2.47 c–h	1.66 d	1.26 b–h	5.38 d–h	3.68 d–g
Atlantic × Narragansett	.96 d–k	1.27 e–i	2.23 f–k	2.56 d–h	1.61 cd	1.27 b–h	5.48 e–h	3.86 gh
Atlantic × Rambler	.97 e–k	1.24 d–i	2.20 f–k	2.56 d–h	1.54 bcd	1.23 b–g	5.36 d–h	3.80 e–h
Atlantic × Culver	.91 b–i	1.29 f–i	2.20 f–k	2.62 e–i	1.57 bcd	1.27 b–h	5.45 e–h	3.83 fgh
Atlantic × Vernal	.92 b–i	1.26 e–i	2.19 f–k	2.48 c–h	1.54 bcd	1.27 b–h	5.27 c–g	3.73 efg
Buffalo × Lahontan	.89 b–g	1.13 a–e	2.00 b–e	2.29 bcd	1.66 d	1.34 gh	5.27 c–g	3.66 d–g
Buffalo × Culver	.88 a–f	1.21 c–g	2.10 c–g	2.38 b–g	1.51 bcd	1.23 b–g	5.11 c–f	3.60 c–f
Culver × Narragansett	1.00 h–k	1.29 f–i	2.29 h–k	2.65 e–i	1.51 bcd	1.18 b–e	5.31 d–h	3.78 e–h
Culver × Vernal	.97 e–k	1.36 hi	2.33 k	2.91 i	1.58 bcd	1.22 b–g	5.71 h	4.01 h
Lahontan × Vernal	.90 b–h	1.23 c–h	2.13 c–h	2.35 b–e	1.60 cd	1.26 b–h	5.22 c–g	3.68 d–g
Narragansett × Williamsburg	.98 f–k	1.34 ghi	2.32 jk	2.48 c–h	1.63 cd	1.26 b–h	5.33 d–h	3.83 fgh
Ranger × Vernal	.90 b–h	1.23 c–h	2.13 c–h	2.46 c–h	1.62 cd	1.25 b–h	5.35 d–h	3.75 efg
Vernal × Rambler	.99 g–k	1.29 f–i	2.28 h–k	2.62 e–i	1.54 bcd	1.20 b–g	5.35 d–h	3.82 fgh
Vernal × Williamsburg	.93 b–j	1.34 ghi	2.27 g–k	2.52 d–h	1.57 bcd	1.32 e–h	5.40 d–h	3.84 gh
Mixtures:								
Atlantic and Buffalo	.88 a–f	1.25 e–i	2.14 c–i	2.51 d–h	1.63 cd	1.31 d–h	5.47 e–h	3.79 e–h
Atlantic and Lahontan	.84 abc	1.20 b–g	2.05 b–f	2.13 ab	1.48 bc	1.26 b–h	4.88 bc	3.46 bcd
Atlantic and Narragansett	.93 b–j	1.25 e–i	2.19 f–k	2.60 e–h	1.55 bcd	1.27 b–h	5.41 d–h	3.80 e–h
Atlantic and Rambler	.92 b–i	1.22 c–h	2.14 c–i	2.69 h–i	1.50 bcd	1.28 b–h	5.49 e–h	3.82 fgh
Atlantic and Vernal	.94 c–k	1.38 i	2.31 ijk	2.66 f–i	1.53 bcd	1.26 b–h	5.44 d–h	3.89 gh
Buffalo and Lahontan	.83 ab	1.10 abc	1.93 ab	2.28 bcd	1.56 bcd	1.23 b–g	5.03 bcd	3.46 bcd
Lahontan and Vernal	.84 abc	1.15 a–f	1.99 bcd	2.20 bc	1.48 bc	1.17 bcd	4.87 bc	3.43 bc
Narragansett and Williamsburg	.86 a–d	1.29 f–i	2.15 c–j	2.45 c–h	1.52 bcd	1.29 c–h	5.27 c–g	3.69 efg
Ranger and Vernal	.95 d–k	1.17 b–f	2.14 c–i	2.55 d–h	1.56 bcd	1.16 bc	5.24 c–g	3.68 d–g
Vernal and Rambler	1.04 k	1.20 b–g	2.25 g–k	2.66 f–i	1.50 bcd	1.15 abc	5.32 d–h	3.79 e–h
Vernal and Williamsburg	.90 b–h	1.34 ghi	2.21 f–k	2.41 b–h	1.53 bcd	1.26 b–h	5.21 c–g	3.74 efg
Parent varieties:								
Atlantic	.88 a–f	1.28 f–i	2.16 d–k	2.57 d–h	1.64 c–d	1.31 d–h	5.55 gh	3.89 gh
Buffalo	.87 a–e	1.25 e–i	2.13 c–h	2.36 b–f	1.52 bcd	1.33 fgh	5.18 c–g	3.66 d–g
Culver	.95 d–k	1.26 e–i	2.21 f–k	2.65 e–i	1.43 b	1.19 b–f	5.27 c–g	3.75 efg
Lahontan	.78 a	1.02 a	1.80 a	1.90 a	1.48 bc	1.14 ab	4.52 a	3.13 a
Narragansett	.94 c–k	1.26 e–i	2.20 f–k	2.52 d–h	1.53 bcd	1.17 bcd	5.20 c–g	3.69 efg
Rambler	1.01 ijk	1.11 a–d	2.12 c–h	2.42 c–h	1.23 a	1.03 a	4.68 ab	3.38 b
Ranger	.91 b–i	1.25 e–i	2.15 c–j	2.48 c–h	1.50 bcd	1.29 c–h	5.30 d–h	3.71 efg
Vernal	1.03 jk	1.27 e–i	2.29 h–k	2.68 ghi	1.54 bcd	1.22 b–g	5.45 e–h	3.85 gh
Williamsburg	.91 b–i	1.26 e–i	2.17 e–k	2.40 b–h	1.60 cd	1.34 gh	5.32 d–h	3.74 efg
Mass polycross	.88 a–f	1.13 a–e	2.00 b–e	2.47 c–h	1.42 b	1.22 b–g	5.10 cde	3.57 b–e

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 26.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Ithaca, N.Y.*[1]

Entries	1959 cuttings				1960 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	2. 23 b–g	1. 77 c–i	1. 21 j	5. 21 f–k	1. 50 bc	1. 31 b–f	0. 98 ghi	3. 80 b–h	4. 51 d–j
Atlantic × Lahontan	2. 09 ab	1. 66 b–e	1. 02 a–d	4. 78 bc	1. 57 bcd	1. 30 a–f	. 89 e–g	3. 76 b–f	4. 28 bcd
Atlantic × Narragansett	2. 41 e–j	1. 94 ij	1. 13 d–j	5. 47 ijk	1. 64 c–f	1. 40 d–g	1. 01 i	4. 05 e–m	4. 82 l–o
Atlantic × Rambler	2. 45 f–j	1. 81 c–j	1. 09 c–i	5. 35 g–k	1. 73 d–i	1. 37 b–g	. 97 f–i	4. 08 g–m	4. 71 i–o
Atlantic × Culver	2. 48 g–j	1. 84 f–j	1. 10 c–j	5. 43 h–k	1. 68 c–h	1. 38 c–g	. 92 c–i	3. 98 d–m	4. 68 h–o
Atlantic × Vernal	2. 39 e–j	1. 78 c–i	1. 11 c–j	5. 27 f–k	1. 75 d–i	1. 35 b–g	. 95 d–i	4. 04 e–m	4. 69 i–o
Buffalo × Lahontan	2. 13 abc	1. 62 bc	1. 06 b–g	4. 81 bcd	1. 43 ab	1. 26 a–d	. 91 c–h	3. 59 bc	4. 25 bc
Buffalo × Culver	2. 24 b–g	1. 85 f–j	1. 12 d–j	5. 21 f–k	1. 66 c–f	1. 30 a–f	. 93 d–i	3. 87 c–j	4. 60 f–m
Culver × Narragansett	2. 47 f–j	1. 79 c–i	1. 13 d–j	5. 39 h–k	1. 75 d–i	1. 43 efg	. 93 d–i	4. 10 h–m	4. 75 j–o
Culver × Vernal	2. 32 b–i	1. 85 f–j	1. 11 c–j	5. 28 f–k	1. 78 e–i	1. 36 b–g	. 91 c–h	4. 02 d–m	4. 69 i–o
Lahontan × Vernal	2. 25 b–h	1. 81 e–j	1. 08 b–h	5. 13 c–i	1. 67 c–g	1. 35 b–g	. 98 ghi	3. 97 d–m	4. 63 g–n
Narragansett × Williamsburg	2. 41 e–j	1. 94 ij	1. 14 e–j	5. 48 ijk	1. 72 d–i	1. 49 g	. 96 e–i	4. 16 i–m	4. 84 mno
Ranger × Vernal	2. 35 c–j	1. 81 e–j	1. 15 f–j	5. 31 f–k	1. 79 e–i	1. 40 d–g	. 98 ghi	4. 18 j–m	4. 68 h–o
Vernal × Rambler	2. 50 hij	1. 77 c–i	1. 11 c–j	5. 39 h–k	1. 72 d–i	1. 33 b–f	. 88 c–f	3. 93 d–k	4. 64 g–o
Vernal × Williamsburg	2. 24 b–g	1. 79 c–i	1. 20 ij	5. 24 f–k	1. 69 c–i	1. 36 b–g	. 99 hi	4. 04 e–m	4. 60 f–m
Mixtures:									
Atlantic and Buffalo	2. 16 a–e	1. 85 f–j	1. 20 ij	5. 21 f–k	1. 82 f–i	1. 38 c–g	. 95 d–i	4. 16 i–m	4. 61 f–m
Atlantic and Lahontan	2. 30 b–i	1. 80 d–j	1. 12 d–j	5. 22 f–k	1. 76 d–i	1. 32 b–f	. 93 d–i	4. 01 d–m	4. 57 f–l
Atlantic and Narragansett	2. 25 b–h	1. 89 g–j	1. 17 g–j	5. 31 f–k	1. 88 i	1. 37 b–g	. 96 e–i	4. 22 klm	4. 76 j–o
Atlantic and Rambler	2. 24 b–g	1. 80 d–j	1. 15 f–j	5. 18 e–k	1. 74 d–i	1. 31 b–f	. 97 f–i	4. 02 d–m	4. 65 g–o
Atlantic and Vernal	2. 38 d–j	1. 97 j	1. 19 hij	5. 54 k	1. 86 ghi	1. 42 efg	. 96 e–i	4. 25 lm	4. 89 no
Buffalo and Lahontan	2. 12 abc	1. 63 bcd	1. 04 b–f	4. 78 bc	1. 61 cde	1. 32 b–f	. 83 bc	3. 75 b–e	4. 30 b–e
Lahontan and Vernal	2. 46 f–j	1. 70 b–f	1. 03 a–e	5. 19 e–k	1. 70 d–i	1. 29 a–e	. 92 c–i	3. 92 d–k	4. 59 f–m
Narragansett and Williamsburg	2. 26 b–i	1. 80 d–j	1. 16 g–j	5. 22 f–k	1. 75 d–i	1. 37 b–g	. 93 d–i	4. 05 e–m	4. 60 f–m
Ranger and Vernal	2. 28 b–i	1. 76 c–h	1. 09 c–i	5. 14 c–j	1. 75 d–i	1. 30 a–f	. 87 cde	3. 92 d–k	4. 53 e–k
Vernal and Rambler	2. 51 ij	1. 86 f–j	1. 04 b–f	5. 41 h–k	1. 69 c–i	1. 34 b–g	. 91 c–h	3. 95 d–m	4. 66 g–o
Vernal and Williamsburg	2. 32 b–i	1. 70 b–f	1. 13 d–j	5. 15 d–j	1. 63 c–f	1. 33 b–f	. 89 c–g	3. 85 c–i	4. 54 e–k
Parent varieties:									
Atlantic	2. 36 c–j	1. 90 hij	1. 21 j	5. 47 ijk	1. 74 d–i	1. 37 b–g	. 96 e–i	4. 06 f–m	4. 79 ko
Buffalo	2. 22 b–f	1. 72 b–g	1. 13 d–j	5. 08 e–h	1. 63 c–f	1. 22 ab	. 93 d–i	3. 78 b–g	4. 42 c–h
Culver	2. 37 c–j	1. 70 b–f	1. 00 abc	5. 08 e–h	1. 66 c–f	1. 23 abc	. 91 c–h	3. 82 b–h	4. 39 b–f
Lahontan	1. 93 a	1. 44 a	. 93 a	4. 31 a	1. 33 a	1. 16 a	. 77 ab	3. 27 a	3. 74 a
Narragansett	2. 39 e–j	1. 92 hij	1. 14 e–j	5. 45 h–k	1. 75 d–i	1. 45 fg	. 90 c–h	4. 09 g–m	4. 77 j–o
Rambler	2. 19 b–e	1. 57 ab	. 93 a	4. 67 b	1. 67 c–g	1. 16 a	. 73 a	3. 55 b	4. 15 b
Ranger	2. 26 b–i	1. 64 b–e	1. 06 b–g	4. 97 b–f	1. 65 c–f	1. 32 b–f	. 92 c–i	3. 89 d–j	4. 41 c–g
Vernal	2. 59 j	1. 86 f–j	1. 06 b–g	5. 51 jk	1. 87 hi	1. 43 efg	. 97 f–i	4. 26 m	4. 90 o
Williamsburg	2. 11 ab	1. 78 c–i	1. 13 d–j	5. 00 b–g	1. 68 c–h	1. 34 b–g	. 92 c–i	3. 94 d–l	4. 46 c–i
Mass polycross	2. 30 b–i	1. 56 ab	. 98 ab	4. 84 b–e	1. 64 c–f	1. 22 ab	. 86 cd	3. 73 bcd	4. 26 bc

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 27.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Raleigh, N.C.*[1]

Entries	1959 cuttings				1960 cuttings					2-year average
	1st	2d	3d	Total	1st	2d	3d	4th	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:										
Atlantic × Buffalo	1. 51 a–h	0. 76 b–h	0. 96 d–j	3. 24 c–i	1. 08 d–i	0. 71 no	0. 72 fg	1. 10 f	3. 62 mn	3. 42 g–m
Atlantic × Lahontan	1. 46 a–f	. 75 b–g	. 86 b–h	3. 07 b–f	. 93 b–e	. 65 i–n	. 67 c–g	1. 04 c–f	3.28 d–j	3. 18 d–g
Atlantic × Narragansett	1. 66 fgh	. 79 b–h	. 86 b–h	3. 35 f–i	1. 17 hi	. 72 o	. 73 fg	1. 05 c–f	3.66 n	3. 50 klm
Atlantic × Rambler	1. 58 d–h	. 74 b–g	. 92 c–j	3. 24 c–i	1. 12 e–i	. 62 f–l	. 69 d–g	1. 03 c–f	3. 47 h–n	3. 35 f–m
Atlantic × Culver	1. 60 e–h	. 85 d–h	. 95 d–j	3. 40 f–i	1. 18 i	. 66 j–o	. 71 efg	1. 03 c–f	3. 52 j–n	3. 48 j–m
Atlantic × Vernal	1. 53 a–h	. 84 c–h	. 95 d–j	3. 33 e–i	1. 06 c–i	. 66 j–o	. 69 d–g	1. 11 f	3. 52 j–n	3. 45 i–m
Buffalo × Lahontan	1. 46 a–f	. 71 b–f	. 83 b–e	2.98 b–e	. 92 bcd	. 62 f–l	. 64 b–g	1.05 c–f	3. 23 d–h	3. 09 de
Buffalo × Culver	1. 33 a	. 74 b–g	. 92 c–j	3. 05 b–f	1. 01 b–i	. 60 e–j	. 68 c–g	1. 04 c–f	3. 35 e–l	3. 15 def
Culver × Narragansett	1. 57 c–h	. 74 b–g	. 82 bcd	3. 17 c–h	1. 07 d–i	. 58 d–h	. 60 b–e	. 96 a–d	3. 24 d–h	3. 18 d–g
Culver × Vernal	1. 49 a–g	. 81 b–h	. 84 b–f	3. 14 c–g	1. 16 hi	. 57 c–g	. 64 b–g	1. 09 ef	3. 44 g–n	3. 27 d–k
Lahontan × Vernal	1. 69 gh	. 86 d–h	. 86 b–h	3. 37 f–i	1. 03 b–i	. 60 e–j	. 67 c–g	1. 02 c–f	3. 29 d–k	3. 35 f–m
Narragansett × Williamsburg	1. 60 e–h	. 85 d–h	. 99 f–j	3. 46 ghi	1. 02 b–i	. 68 l–o	. 74 g	1. 08 def	3. 51 j–n	3. 51 klm
Ranger × Vernal	1. 54 b–h	. 82 b–h	. 85 b–g	3. 19 c–i	1. 02 b–i	. 58 d–h	. 63 b–g	1. 02 c–f	3. 20 d–g	3. 22 d–i
Vernal × Rambler	1. 53 a–h	. 82 b–h	. 86 b–h	3. 09 c–f	1. 10 d–i	. 56 b–f	. 60 b–e	. 97 a–e	3. 23 d–h	3. 21 d–i
Vernal × Williamsburg	1. 39 a–d	. 78 b–h	. 95 d–j	3. 11 c–g	1. 05 c–i	. 66 j–o	. 66 b–g	1. 07 def	3. 46 h–n	3. 28 d–l
Mixtures:										
Atlantic and Buffalo	1. 52 a–h	. 83 b–h	1. 05 j	3. 41 f–i	1. 02 b–i	. 67 k–o	. 72 fg	1. 05 c–f	3. 49 i–n	3. 43 h–m
Atlantic and Lahontan	1. 51 a–h	. 75 b–g	. 86 b–h	3. 12 c–g	. 96 b–g	. 64 h–m	. 65 b–g	1. 02 c–f	3. 29 d–k	3. 19 d-h
Atlantic and Narragansett	1. 58 d–h	. 90 gh	. 99 f–j	3. 41 f–i	1. 15 ghi	. 66 j–o	. 72 fg	1. 05 c–f	3. 56 lmn	3. 52 lm
Atlantic and Rambler	1. 48 a–f	. 73 b–f	. 89 b–i	3. 16 c–g	1. 07 d–i	. 64 h–m	. 71 efg	. 96 a–d	3. 41 f–m	3. 25 d–j
Atlantic and Vernal	1. 65 fgh	. 87 e–h	1. 04 ij	3. 54 i	1. 13 f–i	. 69 mno	. 70 efg	1. 07 def	3. 61 mn	3. 57 m
Buffalo and Lahontan	1. 37 abc	. 70 b–e	. 85 b–g	2. 96 bcd	. 95 b–f	. 59 d–i	. 62 b–f	1. 01 b–f	3. 16 cde	3. 05 cd
Lahontan and Vernal	1. 54 b–h	. 72 b–f	. 77 bc	3. 07 b–f	. 88 abc	. 54 b–e	. 62 b–f	1. 04 c–f	3. 06 cd	3. 06 cd
Narragansett and Williamsburg	1. 52 a–h	. 87 e–h	. 96 d–j	3. 31 d–i	1. 12 e–i	. 69 mno	. 67 c–g	1. 04 c–f	3. 53 k–n	3. 43 h–m
Ranger and Vernal	1. 54 b–h	. 92 h	. 98 e–j	3. 38 f–i	1. 09 d–i	. 60 e–j	. 67 c–g	1. 05 c–f	3. 34 e–l	3. 41 g–m
Vernal and Rambler	1. 55 b–h	. 78 b–h	. 90 b–j	3. 22 c–i	1. 10 d–i	. 51 bc	. 62 b–f	1. 00 b–f	3. 25 d–i	3. 22 d–i
Vernal and Williamsburg	1. 43 a–e	. 80 b–h	. 99 f–j	3. 25 c–i	1. 04 c–i	. 64 h–m	. 73 fg	1. 00 b–f	3. 42 f–n	3. 33 f–l
Parent varieties:										
Atlantic	1. 70 h	. 79 b–h	1. 00 g–j	3. 53 hi	1. 13 f–i	. 69 mno	. 66 b–g	1. 02 c–f	3. 51 j–n	3. 52 lm
Buffalo	1. 41 a–e	. 83 b–h	. 99 f–j	3. 22 c–i	1. 03 b–i	. 63 g–m	. 68 c–g	1. 09 ef	3. 47 h–n	3. 32 e–l
Culver	1. 39 a–d	. 69 bcd	. 83 b–e	2. 91 bc	1. 11 d–i	. 50 b	. 57 bc	1. 00 b–f	3. 19 def	3. 07 cd
Lahontan	1. 46 a–f	. 67 bc	. 75 b	2. 73 b	. 72 a	. 50 b	. 55 b	1. 01 b–f	2. 78 b	2. 76 b
Narragansett	1. 57 c–h	. 78 b–h	. 86 b–h	3. 21 c–i	1. 16 hi	. 63 g–m	. 63 b–g	1. 01 b–f	3. 41 f–m	3. 31 e–l
Rambler	1. 33 a	. 47 a	. 58 a	2. 37 a	. 85 ab	. 32 a	. 41 a	. 88 a	2. 43 a	2. 43 a
Ranger	1. 42 a–e	. 78 b–h	. 93 d–j	3. 14 c–g	. 98 b–h	. 57 c–g	. 63 b–g	1. 02 c–f	3. 19 def	3. 16 def
Vernal	1. 70 h	. 86 d–h	. 91 c–j	3. 47 ghi	1. 13 f–i	. 61 f–k	. 69 d–g	. 94 abc	3. 36 e–l	3. 41 g–m
Williamsburg	1. 35 ab	. 77 b–h	1. 01 hij	3. 16 c–g	. 98 b–h	. 67 k–o	. 71 efg	1. 05 c–f	3. 41 f–m	3. 28 d–l
Mass polycross	1. 38 a–d	. 66 b	. 90 b–j	2. 73 b	. 96 b–g	. 53 bcd	. 58 bcd	. 90 ab	2. 95 bc	2. 87 bc

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 28.—*Adjusted hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, University Park, Pa.*[1]

Entries	1959 cuttings				1960 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	1.82 a–d	1.10 c–h	1.38 ij	4.25 c–h	2.06 e–h	1.57 jk	0.69 fg	4.32 fg	4.33 d–k
Atlantic × Lahontan	1.90 b–g	1.06 b–f	1.19 b–e	4.16 bcd	1.90 b–e	1.41 c–i	.65 c–g	3.95 c–f	4.05 b–e
Atlantic × Narragansett	2.11 c–i	1.24 h–k	1.34 g–j	4.69 i–l	2.03 e–h	1.56 ijk	.69 fg	4.28 fg	4.50 i–l
Atlantic × Rambler	2.10 c–i	1.20 f–j	1.31 e–j	4.60 f–k	2.03 e–h	1.50 f–k	.64 c–g	4.17 efg	4.41 f–l
Atlantic × Culver	2.10 c–i	1.20 f–j	1.41 j	4.71 jkl	2.09 e–h	1.48 e–k	.67 efg	4.24 efg	4.49 i–l
Atlantic × Vernal	2.12 d–i	1.18 e–j	1.30 e–j	4.66 ijk	2.07 e–h	1.56 ijk	.71 g	4.34 fg	4.47 g–l
Buffalo × Lahontan	1.83 a–e	1.01 bc	1.21 b–g	4.05 bc	1.73 abc	1.42 c–j	.58 b–f	3.73 bcd	3.90 bc
Buffalo × Culver	2.17 f–i	1.10 c–h	1.33 g–j	4.62 f–k	1.97 d–h	1.47 e–k	.66 d–g	4.09 d–g	4.34 d–k
Culver × Narragansett	2.10 c–i	1.28 jk	1.32 f–j	4.69 i–l	2.12 fgh	1.44 d–j	.61 b–g	4.17 efg	4.46 g–l
Culver × Vernal	2.14 e–i	1.24 h–k	1.36 hij	4.74 jkl	2.13 fgh	1.44 d–j	.61 b–g	4.19 efg	4.48 h–l
Lahontan × Vernal	1.97 b–h	1.08 b–g	1.21 b–g	4.24 c–f	2.03 e–h	1.52 g–k	.62 c–g	4.17 efg	4.21 c–j
Narragansett × Williamsburg	2.12 d–i	1.17 d–j	1.35 hij	4.63 g–k	1.97 d–h	1.60 k	.66 d–g	4.23 efg	4.48 h–l
Ranger × Vernal	2.19 f–i	1.13 c–i	1.32 f–j	4.64 h–k	2.06 e–h	1.43 d–j	.59 b–g	4.07 d–g	4.37 e–k
Vernal × Rambler	2.07 c–i	1.17 d–j	1.34 g–j	4.55 e–k	2.02 e–h	1.41 c–i	.55 b–e	3.99 def	4.31 d–k
Vernal × Williamsburg	2.14 e–i	1.17 d–j	1.33 g–j	4.69 i–l	1.93 c–g	1.47 e–k	.67 efg	4.07 d–g	4.35 d–k
Mixtures:									
Atlantic and Buffalo	2.04 b–i	1.13 c–i	1.34 g–j	4.50 d–k	1.89 b–e	1.42 c–j	.64 c–g	3.96 c–f	4.25 d–k
Atlantic and Lahontan	1.96 b–h	1.06 b–f	1.26 c–i	4.31 c–i	2.02 e–h	1.51 g–k	.67 efg	4.20 efg	4.21 c–j
Atlantic and Narragansett	2.26 hi	1.24 h–k	1.29 e–j	4.79 kl	2.09 e–h	1.52 g–k	.71 g	4.32 fg	4.58 kl
Atlantic and Rambler	1.99 b–h	1.13 c–i	1.27 d–i	4.38 c–j	1.99 e–h	1.53 h–k	.63 c–g	4.15 efg	4.26 d–k
Atlantic and Vernal	2.21 ghi	1.21 g–j	1.34 g–j	4.79 kl	2.14 gh	1.62 k	.70 f–g	4.46 g	4.55 jkl
Buffalo and Lahontan	1.76 ab	.95 ab	1.15 bcd	3.86 b	1.78 a–d	1.34 b–e	.60 b–g	3.73 bcd	3.80 b
Lahontan and Vernal	1.99 b–h	1.06 b–f	1.16 bcd	4.20 b–e	2.01 e–h	1.41 c–i	.56 b–e	3.99 def	4.10 b–f
Narragansett and Williamsburg	2.15 f–i	1.18 e–j	1.35 hij	4.76 jkl	1.99 e–h	1.55 h–k	.63 c–g	4.17 efg	4.39 f–l
Ranger and Vernal	2.13 d–i	1.15 c–j	1.35 hij	4.64 h–k	1.97 d–h	1.50 f–k	.58 b–f	4.05 d–g	4.31 d–k
Vernal and Rambler	1.97 b–h	1.19 f–j	1.29 e–j	4.45 d–k	2.06 e–h	1.37 b–g	.53 bc	3.96 c–f	4.20 c–i
Vernal and Williamsburg	1.99 b–h	1.20 f–j	1.34 g–j	4.61 f–k	1.97 d–h	1.55 h–k	.63 c–g	4.15 efg	4.33 d–k
Parent varieties:									
Atlantic	2.14 e–i	1.15 c–j	1.39 ij	4.68 i–l	2.06 e–h	1.53 h–k	.70 fg	4.29 fg	4.48 h–l
Buffalo	1.89 b–f	1.03 bcd	1.30 e–j	4.21 b–e	1.97 d–h	1.40 b–h	.63 c–g	4.00 def	4.14 c–h
Culver	2.27 hi	1.10 c–h	1.24 c–h	4.61 f–k	2.02 e–h	1.28 bc	.53 bc	3.84 b–e	4.19 c–i
Lahontan	1.58 a	.83 a	1.00 a	3.42 a	1.72 ab	1.26 b	.49 b	3.47 b	3.41 a
Narragansett	2.13 d–i	1.26 ijk	1.38 ij	4.75 jkl	1.97 d–h	1.51 g–k	.63 c–g	4.11 d–g	4.48 h–l
Rambler	1.92 b–g	.94 ab	1.11 b	4.04 bc	1.59 a	1.00 a	.27 a	2.86 a	3.43 a
Ranger	2.16 f–i	1.01 bc	1.14 bc	4.31 c–i	1.90 b–e	1.31 bcd	.54 bcd	3.74 bcd	4.02 bcd
Vernal	2.31 i	1.37 k	1.38 ij	5.05 l	2.18 h	1.60 k	.67 efg	4.45 g	4.72 l
Williamsburg	1.80 abc	1.04 b–e	1.33 g–j	4.18 b–e	1.92 b–f	1.48 e–k	.64 c–g	4.03 def	4.13 c–g
Mass polycross	1.96 b–h	1.02 bc	1.20 b–f	4.24 c–f	1.75 abc	1.35 b–f	.49 b	3.58 bc	3.89 bc

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 29.—*Hay yields per acre of alfalfa variety crosses, mixtures, and parent varieties by cuttings and seasons, Madison, Wis.*[1]

Entries	1959 cuttings				1960 cuttings				2-year average
	1st	2d	3d	Total	1st	2d	3d	Total	
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Crosses:									
Atlantic × Buffalo	1. 80 c–g	1. 14 a–d	0. 91 e–h	3. 85 b–f	1. 81 d–g	1. 68 fg	1. 37 f–k	4. 86 hij	4. 35 c–h
Atlantic × Lahontan	1. 62 bc	1. 14 a–d	. 74 b	3. 50 bc	1. 67 bcd	1. 58 c–g	1. 37 f–k	4. 62 d–i	4. 06 bc
Atlantic × Narragansett	1. 97 e–k	1. 20 a–e	. 91 e–h	4. 07 c–h	1. 70 cde	1. 60 c–g	1. 34 f–k	4. 64 d–i	4. 36 c–h
Atlantic × Rambler	2. 18 j–m	1. 39 a–e	. 93 fgh	4. 50 f–i	1. 69 b–e	1. 29 b	1. 31 e–i	4. 28 c	4. 39 c–h
Atlantic × Culver	1. 92 e–j	1. 11 a–d	. 91 e–h	3. 95 c–g	1. 73 c–f	1. 62 c–g	1. 32 e–j	4. 67 d–i	4. 31 c–g
Atlantic × Vernal	2. 03 f–l	1. 32 a–e	. 94 gh	4. 30 e–h	1. 73 c–f	1. 62 c–g	1. 31 e–i	4. 66 d–i	4. 48 d–h
Buffalo × Lahontan	1. 65 bcd	1. 31 a–e	. 80 b–e	3. 76 b–e	1. 60 bc	1. 59 c–g	1. 31 e–i	4. 50 c–f	4. 13 b–e
Buffalo × Culver	1. 98 e–k	1. 28 a–e	. 87 d–g	4. 14 c–h	1. 77 def	1. 69 fg	1. 43 jk	4. 89 hij	4. 51 e–h
Culver × Narragansett	2. 21 klm	1. 49 de	. 95 ghi	4. 65 hi	1. 76 c–f	1. 67 fg	1. 34 f–k	4. 76 e–i	4. 71 h
Culver × Vernal	2. 15 i–m	1. 14 a–d	. 91 e–h	4. 21 d–h	1. 87 fg	1. 66 fg	1. 34 f–k	4. 87 hij	4. 54 fgh
Lahontan × Vernal	1. 86 c–h	1. 31 a–e	. 82 b–f	3. 99 c–g	1. 75 c–f	1. 64 d–g	1. 34 f–k	4. 73 e–i	4. 36 c–h
Narragansett × Williamsburg	1. 73 cde	1. 01 a	. 86 c–g	3. 61 bcd	1. 78 def	1. 67 fg	1. 45 k	4. 89 hij	4. 25 b–f
Ranger × Vernal	2. 12 h–m	1. 28 a–e	. 92 fgh	4. 32 e–h	1. 73 c–f	1. 57 c–g	1. 36 f–k	4. 66 d–i	4. 49 e–h
Vernal × Rambler	2. 27 lm	1. 39 a–e	1. 00 hi	4. 66 hi	1. 75 c–f	1. 45 c	1. 19 bcd	4. 39 cd	4. 53 fgh
Vernal × Williamsburg	1. 89 d–i	1. 06 abc	. 93 fgh	3. 88 b–f	1. 95 g	1. 67 fg	1. 45 k	5. 07 j	4. 48 d–h
Mixtures:									
Atlantic and Buffalo	1. 76 c–f	1. 19 a–e	. 88 d–g	3. 83 b–e	1. 78 def	1. 69 fg	1. 39 g–k	4. 87 hij	4. 35 c–h
Atlantic and Lahontan	1. 64 bc	1. 19 a–e	. 78 bcd	3. 61 bcd	1. 68 b–e	1. 60 c–g	1. 30 e–h	4. 57 d–g	4. 09 bcd
Atlantic and Narragansett	1. 92 e–i	1. 25 a–e	. 90 e–h	4. 08 c–h	1. 75 c–f	1. 70 g	1. 37 f–k	4. 82 g–j	4. 45 d–h
Atlantic and Rambler	2. 08 h–m	1. 36 a–e	. 93 fgh	4. 38 e–i	1. 68 b–e	1. 62 c–g	1. 27 c–f	4. 57 d–g	4. 47 d–h
Atlantic and Vernal	2. 05 g–l	1. 25 a–e	. 94 gh	4. 24 d–h	1. 78 def	1. 60 c–g	1. 40 g–k	4. 78 f–i	4. 51 e–h
Buffalo and Lahontan	1. 47 b	1. 04 ab	. 76 bc	3. 28 ab	1. 54 b	1. 61 c–g	1. 37 f–k	4. 51 c–f	3. 90 b
Lahontan and Vernal	1. 94 e–k	1. 31 a–e	. 84 b–g	4. 09 c–h	1. 70 cde	1. 56 c–g	1. 18 bc	4. 44 cd	4. 27 c–f
Narragansett and Williamsburg	1. 94 e–k	1. 40 a–e	. 95 ghi	4. 30 e–h	1. 84 efg	1. 66 fg	1. 40 g–k	4. 90 ij	4. 60 fgh
Ranger and Vernal	2. 20 klm	1. 44 cde	. 94 gh	4. 58 ghi	1. 75 c–f	1. 57 c–g	1. 29 d–g	4. 61 d–h	4. 60 fgh
Vernal and Rambler	2. 33 m	1. 58 e	1. 05 i	4. 96 i	1. 75 c–f	1. 48 cde	1. 21 b–e	4. 43 cd	4. 70 gh
Vernal and Williamsburg	1. 97 e–k	1. 12 a–d	. 92 fgh	4. 01 c–h	1. 76 c–f	1. 65 efg	1. 35 f–k	4. 76 e–i	4. 38 c–h
Parent varieties:									
Atlantic	2. 00 e–l	1. 20 a–e	. 92 fgh	4. 13 c–h	1. 76 c–f	1. 70 g	1. 36 f–k	4. 81 g–j	4. 47 d–h
Buffalo	1. 75 cde	1. 23 a–e	. 90 e–h	3. 88 b–f	1. 71 c–f	1. 60 c–g	1. 42 ijk	4. 73 e–i	4. 30 c–f
Culver	1. 98 e–k	1. 41 bc	. 89 e–h	4. 28 e–h	1. 67 bcd	1. 58 c–j	1. 27 c–f	4. 52 c–f	4. 40 c–h
Lahontan	1. 08 a	1. 21 a–e	. 61 a	2. 91 a	1. 34 a	1. 47 cd	1. 11 b	3. 92 b	3. 41 a
Narragansett	2. 09 h–m	1. 30 a–e	. 93 fgh	4. 32 e–h	1. 74 c–f	1. 68 fg	1. 34 f–k	4. 76 e–i	4. 54 fgh
Rambler	2. 20 klm	1. 29 a–e	. 91 e–h	4. 40 e–i	1. 60 bc	. 95 a	. 86 a	3. 41 a	3. 90 b
Ranger	2. 05 g–l	1. 16 a–d	. 85 c–g	4. 05 c–h	1. 69 b–e	1. 52 c–f	1. 32 f–j	4. 54 c–g	4. 30 c–f
Vernal	2. 10 h–m	1. 26 a–e	. 95 ghi	4. 32 e–h	1. 79 def	1. 53 c–g	1. 32 e–j	4. 63 d–i	4. 48 d–h
Williamsburg	1. 78 c–g	1. 27 a–e	. 92 fgh	3. 97 c–g	1. 77 def	1. 68 fg	1. 41 h–k	4. 86 hij	4. 42 c–h
Mass polycross	1. 91 d–j	1. 26 a–e	. 88 d–g	4. 05 c–h	1. 66 bcd	1. 54 c–g	1. 29 d–g	4. 49 cde	4. 27 c–f

[1] Means having one or more letters in common are not different at 5-percent level by Duncan's multiple range test.

TABLE 30.—*Scores for growth characteristics of alfalfa variety crosses, mixtures, and parent varieties* [1]

Entries	Seedling vigor		Spring growth	Fall growth								Recovery after first cut						
	Indiana Sept. 1958	Kansas Oct. 1958	Nebraska Apr. 1960	Indiana		Kansas Oct. 1959	Minnesota Oct. 1959	Nebraska Oct. 1960	North Carolina Oct. 1959	Pennsylvania Sept. 1960	Wisconsin Sept. 1959	Indiana Aug. 1959	Kansas June 1959	Minnesota 1959	Nebraska July 1959	North Carolina May 1959	Pennsylvania July 1959	Wisconsin 1960
				Oct. 1959	1960													
Crosses:																		
Atlantic × Buffalo	4.0	3.3	3.0	2.7	3.0	3.2	2.3	3.7	3.2	1.3	2.5	3.8	3.2	3.7	3.5	2.7	4.7	2.3
Atlantic × Lahontan	3.7	3.0	1.3	2.5	3.0	3.2	2.5	3.0	4.7	1.5	2.5	3.0	3.2	3.7	3.5	2.3	4.7	1.8
Atlantic × Narragansett	5.2	3.7	2.8	3.2	4.8	4.8	2.7	5.0	4.3	2.3	4.5	4.8	3.7	3.2	4.0	3.5	5.0	3.5
Atlantic × Rambler	5.3	4.3	4.0	2.7	4.8	4.5	2.8	5.0	3.8	2.5	5.3	4.8	4.2	3.7	4.3	3.0	4.8	4.5
Atlantic × Culver	5.3	3.8	4.0	2.8	4.5	5.2	2.5	5.0	4.2	2.7	4.3	5.2	3.7	3.8	4.0	3.3	5.3	4.5
Atlantic × Vernal	4.3	3.5	3.2	3.2	4.2	3.0	3.0	3.8	3.5	2.5	4.0	4.8	3.5	3.8	4.2	2.5	4.8	3.3
Buffalo × Lahontan	3.5	2.2	1.2	2.0	2.0	2.2	2.0	2.2	3.5	1.0	1.5	3.5	2.5	3.2	3.2	2.8	4.3	1.3
Buffalo × Culver	5.2	3.2	3.0	2.0	2.5	3.3	2.7	3.5	4.2	1.5	3.3	5.2	3.0	3.8	3.7	3.7	5.0	3.0
Culver × Narragansett	5.5	4.3	4.2	3.3	5.3	5.5	3.0	5.5	5.2	3.7	4.8	4.8	4.2	3.2	4.2	3.8	5.2	3.8
Culver × Vernal	6.3	4.8	4.2	4.0	5.7	5.8	3.2	5.8	4.7	3.8	5.8	4.7	4.8	3.7	4.0	4.0	5.3	4.8
Lahontan × Vernal	5.0	3.5	1.7	3.0	3.3	3.7	3.0	3.2	5.2	1.8	3.0	2.8	3.2	3.7	3.7	2.3	4.8	2.3
Narragansett × Williamsburg	4.7	3.3	2.5	2.2	2.8	3.3	2.2	3.8	3.7	1.3	3.8	3.7	3.2	3.3	3.7	2.3	4.7	1.8
Rambler × Vernal	4.5	3.7	3.3	3.0	4.3	4.7	2.3	4.2	4.5	2.5	4.0	4.3	4.0	3.7	4.0	3.2	5.0	3.8
Vernal × Rambler	6.5	5.0	4.8	4.5	6.3	6.3	3.3	6.2	5.7	5.0	7.0	5.8	5.3	3.8	5.2	2.8	5.7	6.0
Vernal × Williamsburg	5.0	3.0	2.3	1.7	3.3	2.8	2.5	3.2	3.2	1.5	3.5	3.8	3.3	3.8	3.7	2.8	4.7	2.0
Mixtures:																		
Atlantic and Buffalo	3.8	3.0	1.7	2.0	2.8	3.7	2.0	3.7	4.3	1.5	2.8	4.3	3.0	3.8	3.3	2.3	4.8	2.0
Atlantic and Lahontan	4.0	3.2	1.2	2.3	2.2	3.0	2.3	2.2	4.5	1.7	2.5	3.0	2.3	3.3	3.2	2.7	5.0	1.8
Atlantic and Narragansett	4.8	3.5	3.7	2.8	4.3	4.2	2.2	4.8	4.2	2.3	4.5	4.7	3.2	3.3	4.0	2.7	4.7	3.3
Atlantic and Rambler	5.5	3.8	3.0	2.7	4.2	3.8	2.3	4.2	3.7	2.2	3.3	5.0	3.3	3.5	4.3	3.3	4.7	2.0
Atlantic and Vernal	5.3	3.5	3.2	3.0	4.2	3.8	2.7	4.7	4.0	2.3	5.0	4.5	3.2	3.5	4.0	2.2	5.0	3.5
Buffalo and Lahontan	3.8	3.2	1.3	1.8	2.0	2.7	2.2	2.2	4.2	1.0	2.0	2.8	2.8	3.8	2.7	2.5	4.7	1.5
Lahontan and Vernal	6.0	3.7	1.5	2.7	2.3	3.2	3.0	2.5	5.2	2.2	3.3	3.3	3.3	3.3	3.5	3.2	5.2	3.0
Narragansett and Williamsburg	4.8	3.5	2.2	2.5	3.2	3.2	2.7	3.3	3.8	1.7	3.8	4.7	3.2	4.0	3.8	2.2	4.8	2.0
Ranger and Vernal	4.5	3.5	3.5	3.7	5.3	5.2	2.8	5.0	4.8	3.8	4.8	4.2	4.0	3.2	4.3	2.5	5.2	3.5
Vernal and Rambler	5.8	5.3	4.3	4.3	6.0	5.8	3.2	6.3	4.7	5.0	6.5	5.8	5.0	3.5	5.2	3.8	5.7	6.0
Vernal and Williamsburg	5.3	3.3	2.3	2.3	3.2	3.0	2.3	3.2	3.2	1.3	2.8	3.8	3.3	3.2	4.0	2.7	5.0	2.5
Parent varieties:																		
Atlantic	4.0	3.2	2.8	2.7	3.7	3.8	2.3	3.8	3.7	1.8	3.8	4.5	3.3	3.3	3.7	2.3	4.7	2.5
Buffalo	3.0	2.5	1.7	1.7	1.7	2.8	1.7	3.2	2.5	1.0	2.5	2.3	3.0	3.5	3.2	2.2	4.7	3.0
Culver	6.3	5.0	4.5	3.5	5.7	5.5	3.2	5.7	5.2	4.5	5.3	6.0	4.5	4.3	4.5	3.8	5.7	5.3
Lahontan	4.8	3.2	1.0	2.7	2.3	2.8	3.0	1.3	5.3	1.2	1.0	2.5	2.2	3.0	2.2	2.3	4.5	1.0
Narragansett	6.5	5.3	4.7	3.8	6.2	6.0	3.0	6.0	5.5	4.0	5.5	5.3	4.5	3.7	4.5	3.5	5.0	4.5
Rambler	7.2	6.7	5.8	5.8	9.0	8.0	3.8	8.2	7.0	8.8	8.3	7.7	6.7	4.5	5.8	4.8	7.2	9.0
Ranger	4.7	3.3	3.5	3.3	5.0	4.7	2.5	4.8	4.7	2.3	4.0	4.0	3.8	3.5	4.0	2.7	5.3	2.8
Vernal	5.8	4.7	3.5	4.2	5.8	6.0	3.0	6.2	6.0	4.0	6.3	5.2	4.8	3.5	4.7	3.5	5.2	4.8
Williamsburg	4.3	3.7	2.0	2.0	2.5	2.8	2.0	3.0	3.5	1.3	2.3	3.2	3.3	3.3	3.2	2.8	4.7	1.3
Mass polycross	6.2	4.3	2.7	3.7	4.5	5.0	2.5	4.2	6.0	3.5	5.5	4.8	4.8	3.7	3.8	3.3	5.3	4.0
L.S.D. at 5-percent level	1.2	0.8	0.7	0.6	0.8	0.6	0.5	0.7	1.3	0.8	0.9	1.0	0.5	0.6	0.6	1.0	0.5	0.9
L.S.D. at 1-percent level	1.6	1.1	.9	.8	1.1	.8	.7	.9	1.7	1.0	1.2	1.3	.7	.8	.7	1.3	.7	1.2
Coefficient of variation (percent)	21	19	21	19	18	13	18	14	25	26	16	20	13	16	12	29	9	20

[1] Scores ranged from 1 (most) to 9 except in Minnesota, where scores were 1 to 5.

TABLE 31.—*Estimated percent stand and winter injury of alfalfa variety crosses, mixtures, and parent varieties*

Entries	Stand																		Winter injury	
	Indiana			Iowa	Kansas			Minnesota		Nebraska	New York		Pennsylvania		Wisconsin				Minnesota	Wisconsin
	Sept. 1958	Sept. 1959	June 1960	Fall 1959	Oct. 1958	Oct. 1960	April 1961	Oct. 1958	Oct. 1960	April 1960	Spring 1959	Sept. 1960	Aug. 1958	Sept. 1960	Spring 1959	Spring 1960	Sept. 1960	Sept. 1961	May 1959	May 1959
Crosses:																				
Atlantic × Buffalo	84	89	81	99	99	99	99	95	90	99	61	78	94	91	96	97	92	94	33	6
Atlantic × Lahontan	83	89	85	98	99	99	99	93	88	99	56	75	91	89	98	97	94	91	58	23
Atlantic × Narragansett	75	88	80	98	99	98	98	95	90	99	68	81	94	90	97	96	92	93	19	0
Atlantic × Rambler	83	84	75	96	99	97	97	92	88	99	66	72	86	75	98	96	89	90	8	0
Atlantic × Culver	83	88	80	97	99	98	98	94	86	98	73	76	94	90	97	98	89	92	19	2
Atlantic × Vernal	83	88	80	97	99	99	99	95	87	98	70	76	91	83	98	98	91	93	22	3
Buffalo × Lahontan	84	90	85	96	99	97	96	92	88	98	48	75	94	84	97	96	92	85	50	18
Buffalo × Culver	84	88	82	98	98	98	98	95	89	99	61	78	90	90	98	98	94	94	30	0
Culver × Narragansett	80	87	82	99	99	98	98	93	90	98	60	75	92	87	94	95	91	93	12	1
Culver × Vernal	81	88	82	95	98	98	97	95	87	98	68	77	93	89	99	98	91	94	16	0
Lahontan × Vernal	81	89	83	98	99	99	98	94	88	98	48	72	87	82	96	95	92	88	30	9
Narragansett × Williamsburg	81	88	81	98	99	98	97	95	88	99	63	78	91	91	98	98	94	93	20	2
Ranger × Vernal	86	90	84	98	99	98	97	95	88	97	58	73	94	90	96	97	91	92	16	1
Vernal × Rambler	72	83	72	98	99	98	95	95	82	99	66	75	92	83	98	97	87	91	8	0
Vernal × Williamsburg	82	86	80	98	99	98	98	95	89	98	63	79	94	90	97	96	92	92	30	2
Mixtures:																				
Atlantic and Buffalo	87	90	84	97	99	99	98	95	85	98	63	76	86	84	96	96	92	94	22	6
Atlantic and Lahontan	80	88	82	98	99	99	98	95	88	98	61	72	92	90	97	95	92	90	47	20
Atlantic and Narragansett	82	88	82	98	98	98	97	95	83	98	73	80	88	84	96	96	91	96	12	0
Atlantic and Rambler	82	85	76	96	98	97	97	92	87	95	52	72	88	86	98	96	90	90	20	1
Atlantic and Vernal	86	88	83	96	99	99	98	95	88	97	71	74	92	89	95	96	90	93	8	3
Buffalo and Lahontan	80	88	83	97	99	99	99	94	82	94	44	76	89	85	98	96	93	90	48	25
Lahontan and Vernal	73	82	79	96	98	98	98	95	87	97	53	74	90	83	96	96	90	87	39	11
Narragansett and Williamsburg	81	86	78	97	99	99	98	92	78	94	70	78	93	87	98	97	92	94	20	1
Ranger and Vernal	87	90	85	96	99	99	98	95	88	98	63	71	94	86	98	98	92	92	8	0
Vernal and Rambler	82	85	76	94	99	95	94	95	90	98	59	67	89	81	97	95	84	90	5	0
Vernal and Williamsburg	81	88	81	96	99	99	98	95	85	98	62	72	91	88	98	97	92	91	14	1
Parent varieties:																				
Atlantic	85	90	84	98	99	99	99	95	89	98	68	78	89	87	96	96	92	93	26	2
Buffalo	86	91	86	98	99	99	98	94	87	98	51	75	73	84	97	97	92	93	36	4
Culver	81	88	80	96	99	97	96	91	78	98	63	74	76	73	96	96	90	94	22	2
Lahontan	76	86	82	95	99	99	99	89	33	89	37	69	82	75	97	92	92	58	91	62
Narragansett	74	83	70	96	99	98	97	94	78	98	76	75	90	82	98	96	90	94	11	0
Rambler	73	82	52	92	98	82	75	92	77	96	49	65	76	65	98	96	52	51	4	0
Ranger	74	89	83	97	99	99	99	95	90	98	53	72	93	87	98	98	93	94	9	1
Vernal	67	85	79	96	99	97	96	95	88	99	68	73	94	88	97	96	89	91	9	0
Williamsburg	83	89	79	98	99	99	98	95	80	95	62	77	88	88	97	98	94	91	37	8
Mass polycross	73	83	75	93	99	96	96	92	83	94	48	62	87	70	97	94	86	85	22	4
L.S.D. at 5-percent level	10	6	7	3	-----	2	3	3	10	3	10	5	11	10	2	2	3	6	12	6
L.S.D. at 1-percent level	13	7	9	3	-----	3	4	4	14	4	13	6	14	13	3	2	4	7	16	8
Coefficient of variation (percent)	11	6	7	2	-----	2	2	3	11	3	14	6	11	10	2	1	2	4	35	67

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